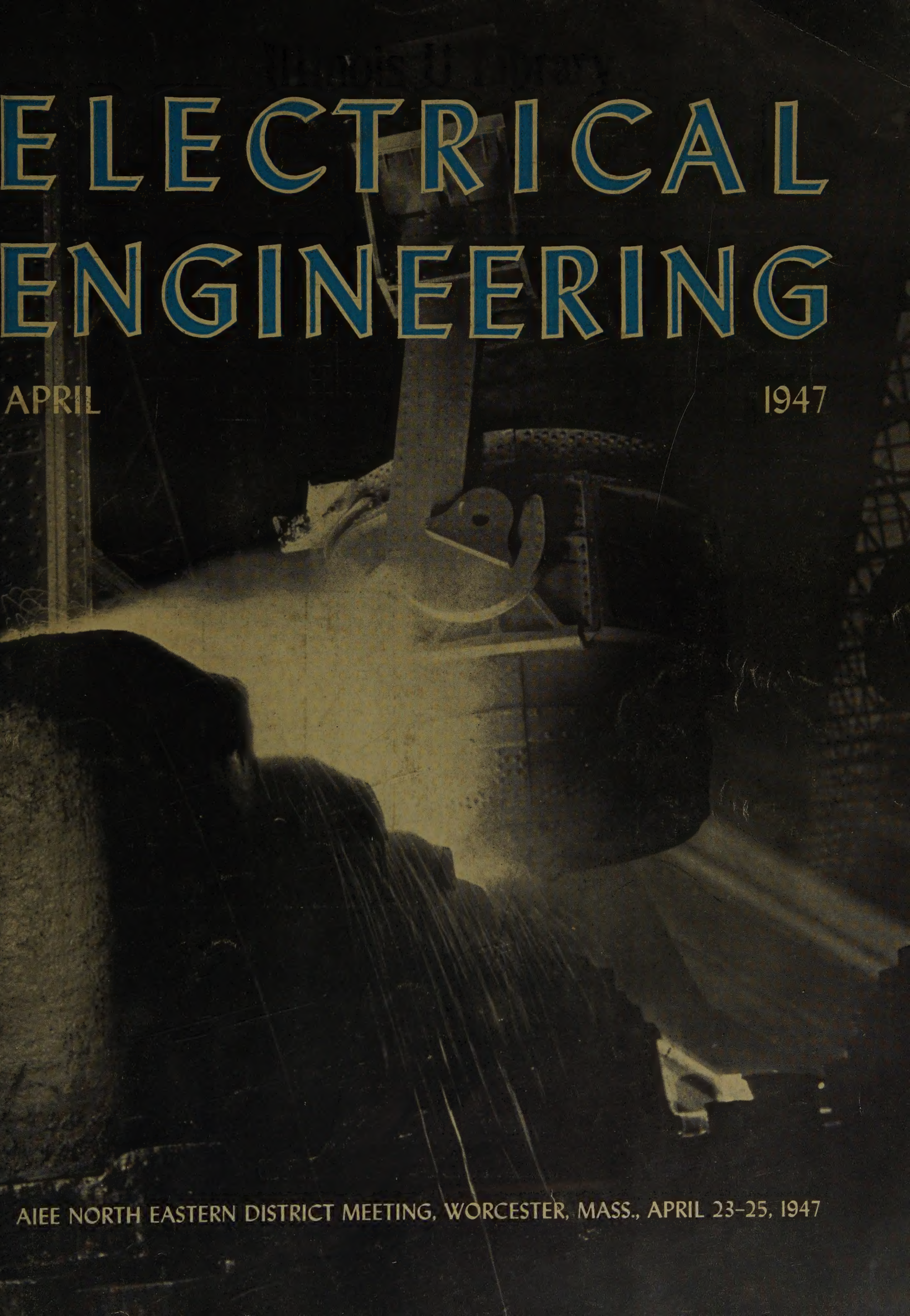
ELECTRICAL ENGINEERING

APRIL 1947



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Electrostatic Ills and Cures of Aircraft

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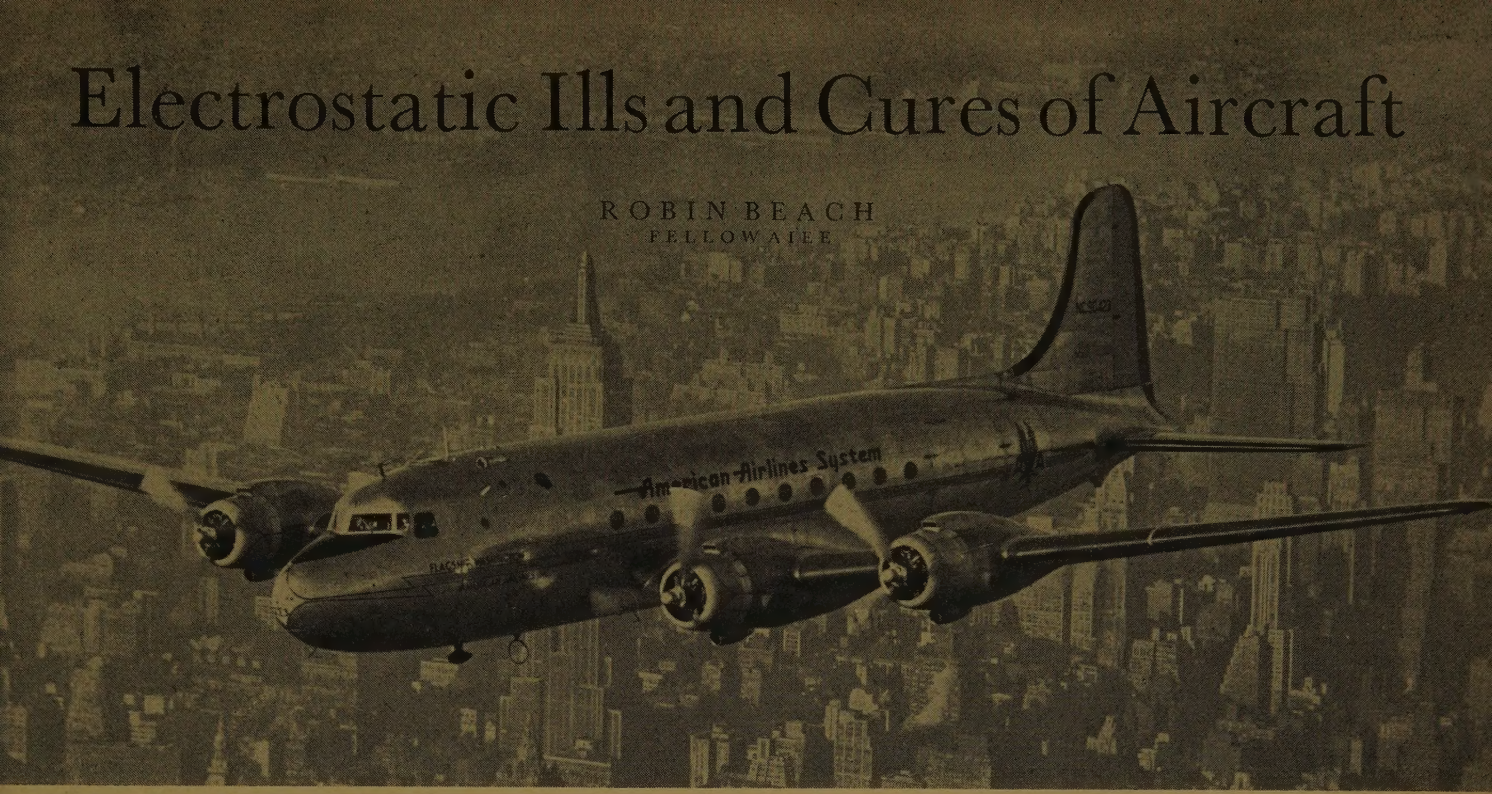

I. Electrification of Airplanes and How It Causes Radio Interference

Aircraft in flight are capable of building up extremely high potentials which, in discharging, interfere with radio communication and navigation equipment, perhaps to such an extent as to render it useless for long periods. The process by which electrification is accumulated and the mechanism by which radio interference is produced are described in this first part of a 2-part article.

DEPENDENCE of high-speed aircraft in flight upon their increasing complements of radio communications equipment and radio flight instruments has given emphasis to the necessity for adequate control of static electricity created on the extensive airfoils. High voltage electrostatic discharges from various parts of airplanes cause serious radio interference, commonly to the extent of obliterating radio communication and of rendering unreliable the indications of radio flight instruments.

These difficulties of air navigation are intensified by the condition that the electrification of airplanes in flight increases about as the cube of the speed. Doubling the speed of flight increases the electrification nearly eight-fold. Thus radio interference is associated intimately with the electric breakdown properties of the air surrounding the airplane, and especially with the degree of ionization to which the gaseous components of the air are subjected by the high potential gradients resulting from the electrification.

THE RADIO INTERFERENCE PROBLEM

As the airplane becomes highly electrified, it begins to discharge itself where the electric field intensities are highest. The action occurs as dielectric breakdown of the ambient air, first as invisible ionization and then at slightly higher potential gradients as visible corona. These ionizing potential gradients appear at those areas of sharpest curvature, such as masts, projecting tubes, pointed parts, rivet burrs, bare wires, tips of propeller blades and wings, and the curved edges of the empennage or tail. Whenever the discharging rate attains parity with the charging rate, the potential of the airplane becomes constant. However, under the varying conditions of electrification by atmospheric agencies from place to place such periods of potential equilibrium are generally of short duration and change rapidly because of the fast travel of the aircraft.

During such electrical discharges at higher intensities than those causing the first appearance of visible corona, tiny sparks occur within so-called ionized "leaders" which also are called "streamers" or "corona brushes." These leaders emanate as a form of corona where the electrically overstressed air is contiguous to those parts of the airplane which possess the sharpest curvatures. The leader sparks create parasitic electromagnetic

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Figure 1. Remains of exploded parts of antenna reel-in box of a DC-4 airplane located to the rear of pilot cabin in belly compartment; explosion resulted from ignition by lightning of flammable vapor-air mixture

radiations which energize the various antennas on the airplane and shock-excite the associated receivers throughout the radio-frequency spectrum. These noise responses interfere with or even obliterate the desired signals. Sometimes such radio interference may block intelligible reception for hours—in the meantime the pilots practically are lost in flight by not having the benefit of radio communication and other aids to air navigation.

The United States Armed Forces have reported that some 25 per cent of the airplane casualties in the Army and Navy during the war, at home and abroad, resulted directly from the obliteration of radio communications and from the erratic behavior of certain radio flight instruments by static interference. Also, the Army stated that more than one per cent of the military aircraft assigned to certain areas of the United States were lost each year as a result of static interference with radio reception.

An indirect cause for other airplane crashes is believed to result from errors of judgment while landing caused by the exhaustion of pilots from excessive ear strain and its resulting nerve fatigue from long-continued loud radio static noise, sometimes lasting for hours at a time. Another insidious cause of airplane catastrophies—especially fires and explosions in the air—is believed to originate from the ignition by electrostatic sparks of flammable mixtures of hydrocarbon vapors. Figure 1 shows parts resulting from such an explosion within the pilot cabin of an airplane on one of the commercial airlines which happened during a thunderstorm.

The gravity of these conditions gave reason for the organization of an extensive research project, sponsored jointly by the Army and Navy, for the investigation of the causes and control of electrification on airplanes. The many variables and the characteristic behavior of these causes in contributing to the electrification of and the electric discharge from airplanes were investigated. This study[1,2] has provided a basis for the better understanding of some of the electrostatic problems encountered in the operation of high-speed aircraft, both military and commercial.

TYPES OF ELECTRIFICATION

The methods by which airplanes in flight become electrified may be classified into two general categories:

1. Contact agencies.
2. Electrostatic induction agencies.

The contact agencies here relate to those physical contacts which are made with the airplane by atmospheric water particles in one of their various—vapor, liquid, or solid—or by other air-borne particles, such as dust and smoke. All these atmospheric components that may cause contact electrification are classified under the heading of "precipitation" static.

Electrostatic induction agencies may cause airplanes to become highly electrified by their proximity to electrically charged clouds. The airplane normally does not acquire so-called "free" charges in this manner, as by precipitation static, but it can become intensely electrified with "bound" charges whereby the highly active ionized leaders which develop cause most severe radio interference.

The electrification thus formed on an airplane varies over wide limits depending, among other factors, upon its distance from the cloud, the degree of cloud electrification, and possible interception by the airplane of powerful ionized leaders probing the intervening atmosphere from the cloud to earth or to other clouds just prior to a stroke of lightning.

There is nothing novel or unexpected from either of these two generic causes for electrification as they have been common sources of electrostatic disturbances and hazards not only to airplanes but also to structures and vehicles on the ground for years past. Over a period of several years, the author has investigated and reported his findings and conclusions [3,4] on many phases of these problems in connection with his applied studies relating to electrostatic hazards and their controls in industries.

PRECIPITATION STATIC

The electrification of airplanes by precipitation agencies is caused directly by contact effects. Electric charges generally are imparted to the surfaces of the

airplane in one or both of the following two ways:

1. By the so-called friction between the surfaces of the airplane and the uncharged particles of precipitation.

2. By the acquisition of electric charges by the airplane from its contact with particles of precipitation which already are electrified.

In electrifying an airplane by so-called frictional contact with uncharged particles, such as snow, ice crystals, hail, rain, fog, clouds, smoke, or dust, two of the worst offenders have been found to be dry snow and ice crystals. In general, this process of contact electrification charges the metallic airfoils with negative electricity, that is, with electrons, while the complementary positive electricity of identical amount flows aft in the slip stream on the receding particles of precipitation.

The physical process underlying electrification by this means is precisely the same as that explained by the author in many of his other publications on applied electrostatics.[3,4,5] The separation of electric charges at a surface in contact with any rapidly moving material, such as so-called stock in industrial operations, electrifies the material with one polarity, be it paper web, textiles, ply-stock, plastic films, or dry snow, and the surface with opposite polarity, such as the processing rolls over which the moving stock passes or the airfoils of an airplane over which the particles of precipitation glide. In this process of charging, electrons pass from the substance possessing the higher dielectric constant to the one of lower value. Because pure water in its liquid and solid phases possesses a relatively high dielectric constant, the surfaces of the airplane normally become negatively charged by this process of frictional contact.

The amount of electricity thus generated —expressed in electrostatic units—is equal, numerically, to a constant multiplied by the difference of the dielectric constants of the two contacting substances. This relationship is known as Coehn's equation. The average value of Coehn's constant, based upon many experiments, is about 4.4. The dielectric constants are available for many substances. Various lists, such as Table I, have been prepared from painstaking research studies on contact electrification—called "contact potential series"—by which any substance in the list when in contact with a substance listed above it acquires a positive charge and the other an equal charge of negative polarity. If the dielectric constants of these substances are known from test, the electrification may be computed to a fair degree of approximation. The farther apart in the list the two contacting substances are the higher is their electrification.

This chimera-like basic relationship has suggested a too obvious solution to electrostatic problems—that of matching dielectric constants. Theoretically, if two different substances with equal dielectric constants are pressed into contact or rubbed together, no electrification results. Practically, such surfaces making contact generally can not be kept free from contaminants and especially from the hydrolyzing action of condensed water vapor from the air and, because of these counteracting conditions, surprisingly high electrification rather than none sometimes may occur. Based upon these erratic and disheartening consequences, experience long since has prompted the abandonment of this means of solving electrostatic problems except in a few very special instances. Repeated and costly attempts to eliminate precipitation static on airplanes by applying lacquer, wax, or paint coatings likewise have culminated in failure.

The various types of precipitation, especially dust, already may be electrified as they approach the airplane, in which instance the particles impart their electric charges to the surfaces during their initial contact. Sometimes, such as in various parts of charged clouds or in electrified dust clouds, great volumes of these particles in space may contain essentially all positive charges or all negative charges. Conditions of high difference of potential with its environment may exist on the aircraft when it enters such electrified space and, because of this process of appropriating the electric charges, the difference of potential is similarly high with respect to its new uncharged surroundings when it leaves the charged space.

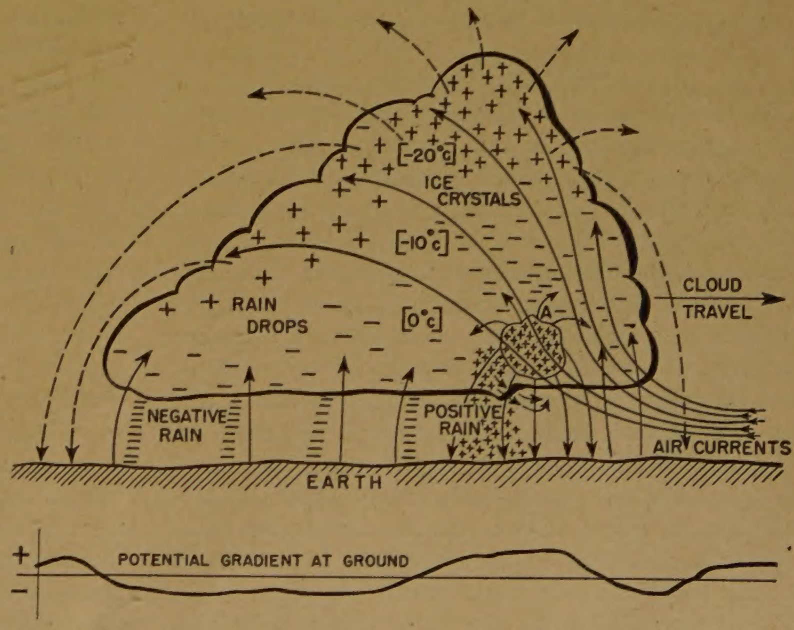


Figure 2. Electric charge regions, electric fields, isothermal strata, rain polarities, induced ground potentials, and air currents of a thundercloud

Revised Simpson theory

Table I. Contact Potential Series*

Negative end of series		
Collodion film	Amber	Cadmium
Gun cotton	Sulphur disk	Gelatin film
Brass	Ebonite plate	Quartz
Celluloid sheet	Paper towel	Linen
Gold	Shellac	Flannel
Silver	Beeswax	Zinc
Copper	Nickel	Crown glass
Tin	Aluminum	Calcite
Antimony	Silk	Flint glass
	Bismuth	
		Positive end of series

* Partial list from table by F. Sanford, *Physical Review*, volume 12, 1918, series 2.

In addition to imparting their electric charges to the surfaces directly by contact, as just described, these particles which now are uncharged subsequently may create electrification, either of the same or of opposite polarity, by the process of friction as they flow aft along the airfoils or leave the airfoils in the presence of a high potential gradient. Obviously, in some instances one of these charging effects partially may compensate the other.

These contact types of electrification long have been notorious sources of disturbance, and indeed causes of hazards, throughout the western plains and the Great American Desert, where blowing sand, dust, or wind-driven dry snow have charged the antennas of local radio stations and wire fences to astounding values of potential. Automobiles, either parked or operating, have been electrified similarly, sometimes causing obliteration of their radio reception or even the failure of their engine ignition. Over these areas, along the eastern slopes of the Cascades and Sierras, many of the worst airplane catastrophies have occurred, particularly on east-to-west trips. Several were attributed to loss of navigational bearings caused by "black out" of radio reception from severe static interference.

INDUCTION STATIC

The electrification of airplanes by induction results from passing through or near a charged cloud. The electric charges on a cloud generally are distributed with an intensely positive center near the lower front, with the upper strata also positively charged[6] but at a much lower field gradient, and with the remainder of the cloud at negative potential. These conditions within a thundercloud are shown in Figure 2, together with approximate isothermal layers, the paths of air flow, the rain polarities, the electric field directions, and the resulting variations of earth potential. These characteristics of electrification on clouds were determined by Simpson and Scrase by balloons equipped with appropriate recording instruments in conjunction with portable instruments on the ground. The origin of electrification lies in the region marked *A*, where breaking and recombining of rain drops generates positive charges on the droplets and negative charges in the air.

The intense electric fields from highly charged clouds, whose potentials above the earth may be of the order of 20,000,000 volts or more, exert their influence for miles. In thunderheads, the near cyclonic wind velocity sometimes generates electric charges with astounding rapidity, electrifying the cloud to lightning-stroke intensities which may discharge and recharge repeatedly at short intervals.

In skirting a charged cloud an airplane undergoes various orientations of its structure with respect to the variously charged volumes of the cloud, these relative positions sometimes changing quite rapidly. Assuming the axis of the wings, at the moment, to be directed toward a positive section of the cloud, as shown in Figure 3, the electrons in the remote wing tip are attracted to the near wing tip, charging it negatively and leaving the remote tip charged with positive electricity. Any change in the strength of the induction field will modify the number of electrons transferred to the near wing tip, this transfer of electric charges being an electric current. If the airplane quickly passes into an electric field of opposite polarity from this or another cloud, the electrons migrate, en masse, to the other wing tip, the one now further from the cloud. This reversal of electrification may be accompanied by relatively large currents through the intervening wing structures. When these changes occur suddenly, the higher the electric charge on the cloud, or the nearer the airplane to the cloud, the greater will be the current. This current will attain its maximum value when a lightning stroke impinges upon one wing tip and passes out of the other, enroute to ground or to an adjacent cloud.

Only about one per cent of all lightning strokes are believed to pass from clouds to earth, the remainder occurring either within sections of the same cloud or between adjacent clouds. When the length or breadth of an airplane intercepts the path of a lightning stroke or passes through the ionized leaders from the cloud, just prior to a lightning stroke, the entire peripheral structure of the airplane may be observed in the dark to be outlined with an intense violet glow of corona, these luminous areas being intensified with brightly radiant paths of ionized leaders from which intense radio interference occurs. Tests have demonstrated that a potential of well over a million volts is required to create "outline corona" on large airplanes. Modern high-speed airplanes cover these localized storm areas quickly and hence such radio interference, although most intense while it lasts, is generally of relatively short duration, continuing only for seconds or a few minutes at most. However, highly electrified air-mass fronts of hundreds of miles in length sometimes parallel the normal course of the airplane in which case severe radio noise would last for hours unless the course of flight were altered.

Highly charged clouds thus can induce very high potential gradients at the wing tips, each tip of opposite polarity—a condition which is unlike that caused by

precipitation static wherein the potential is generally of one kind, usually negative, throughout. Under the influence of these high electric field gradients, as just stated, such prolific ionization occurs that ionized leaders radiate out from the wing tips causing relatively powerful sparks in the now partially conductive air. The more intense the electric potential gradients, the more energy the ionized leaders contain and the more active their inherent sparks.

Lightning strokes have been found by Simpson and Scrase[6] to originate almost invariably near the negative charge centers within the electrified clouds where the average critical breakdown potential gradient is in the order of 10,000 volts per centimeter rather than 31,000 volts per centimeter as for ordinary air at sea level under approximate uniform field distribution. The potential gradients at the earth, whose relative dimensions can be regarded as infinite in comparison with clouds, rarely exceed 100 volts per centimeter, except at tall pointed structures such as lightning rods, steeples, and conductive grounded towers of steel-frame buildings.

Induction charging of objects on the ground, in this same manner, has been described by the author as sometimes creating highly dangerous industrial electrostatic hazards. Tank trucks, used in transporting flammable industrial solvents, when parked on dry concrete or amacite paving, sometimes acquire high electrification as "bound" charge from passing electrified clouds. Because the electrical resistance of the paving and rubber tires through which the electrons must pass from ground onto the truck, or vice versa, may be very high, the time constant of charging may be large—one or more hours. As the cloud later floats away or discharges by a lightning stroke, an unbound or "free" charge of equally high potential to ground is left on the truck. The time constant for the natural leakage discharge of the truck may be almost the same as that for charging. The subsequent sudden discharge of the truck by an inadvertent spark in the presence of flammable vapor mixtures may initiate a fire or an explosion. These have occurred on airplanes, as well as on tank trucks, especially during refueling operations when ungrounded conditions carelessly prevail. Many other similar hazards occasionally develop as a result of the induction charging of extensive metallic areas by clouds. Areas, such as insulated metal roofs, electric transmission lines, improperly grounded storage tanks, and airplanes parked on concrete aprons, have large capacity for the storage of electricity.

In this connection, the author has measured the capacitance to ground of a number of airplanes, some military and some commercial, ranging from small to largest wing spans. All measurements were taken on airplanes parked on concrete aprons outside of hangars, thereby avoiding errors of measurement by the diversion of applied electric fields to nearby surrounding structures. The measured values of capacitance in micromicrofarads are plotted against wing span in feet in Figure 4. Many variables other than wing span affect the capacitance to ground of parked airplanes and hence the curve indicates values to a precision only of the order of from 10 to 15 per cent, although the measured and plotted values are within a precision of 5 per cent. The equations shown in Figure 4 were derived by the author to express the approximate capacitance in micromicrofarads of an airplane, either on the ground or in flight, as a function of the wing span in feet. The test data are tabulated for reference in Table II.

Table II. Values of Capacitance to Ground of Airplanes

Type of Airplane	Man facturer	Wing Span in Feet	Capacitance in Micromicrofarads
Military airplanes			
L-5 liaison aircraft	Stinson	34	670
P-47 fighter	Republic	41	1,040
AT-6 trainer	North American	42	925
B-25 bomber	North American	67	1,380
A-26 medium bomber	Douglas	70	1,350
C-47 cargo ship	Douglas	95	2,050
B-17 bomber	Boeing	104	2,725
Commercial airplanes			
UC-45	Beechcraft	48²/₃	1,150
DC-3	Douglas	95	1,930
DC-3	Douglas	95	1,930
DC-4	Douglas	118	2,380
DC-4	Douglas	118	2,480
DC-4	Douglas	118	2,480
Constellation	Lockheed	123	2,860

In obtaining necessary data from which to prescribe safety measures and practices in handling airplanes in and about hangars, the resistances of the tires and especially of dry concrete or amacite pavements also are required. Military airplanes at Mitchel Field, Mineola, N. Y., which were measured for tire resistance, all were found to utilize conductive rubber of relatively negligible values. Conventional tires on commercial airplanes, all measured in parallel, range around 1,000 and 2,000 megohms, measurements being taken with a 1,000-volt resistance measuring instrument. The resistance of dry pavement, either of concrete or amacite-covered macadam, averages two to three orders higher than that of the conventional tires.

DISTRIBUTION OF CHARGE

The distribution of the electric charges which are imparted to an airplane in flight adjusts itself over the surfaces according to the geometry of the structure. The density of charge is greatest at parts having curvatures of smallest radii, that is, at sharp points, small-sized wires, and trailing edges and tips of airfoils and propeller blades. For example, the density of charge near the tips of the wings, the stabilizers, and the propeller blades is some five to eight times higher than that on the flat areas of the central fuselage. It is for this reason that these parts are the first to develop ionization, the electric potential gradients here first reaching the values at which the ambient air, as a dielectric, begins to break down. The distribution of electric charges

on an airplane and the areas at which visible corona may appear are shown schematically by the surface density of the dots and by the shading lines, respectively, in Figure 5.

In other words, the high electric field strength in the air at the locations of sharp curvature around the airplane cause the free ions normally present in the air to acquire sufficient energy in the form of highly increased velocities to force the outer planetary electrons from surrounding neutral molecules of the gaseous components of the air by the violence of their physical collisions—the well-known process of "ionization by collision." The complete spark spectrum of air, as included in reference 7, shows the definite presence of only nitrogen, oxygen, and argon as component gases, the spectrum lines in the ultraviolet and visible spectra ranging from 0.22879 to 0.79523 micron. Although the ionizing potentials of the several gaseous constituents of air, as shown in Table III, would indicate that the inert gases and helium and hydrogen which are present in air to 0.3 per cent by weight also should show spectral lines, yet their minute amounts apparently do not provide recognizable spectral patterns.

It should be appreciated at this stage, as tests have confirmed, that the potential gradient at which ionization by collision is initiated—the threshold value—is practically independent, under standard atmospheric conditions, of how many free ions may be contained in a unit volume of the electrically stressed[8] air.

This threshold potential gradient at which the air just begins to ionize, standard atmospheric conditions and a uniform electric field distribution being assumed, is about 31,000 volts per centimeter. However, a uniform field distribution exists only in theory; in practice, electric field densities generally vary greatly, depending upon the shape of the electrodes, being most highly concentrated for a given applied voltage at extremely sharp points and to a lesser degree at sharp edges and curves of which airplanes possess an overabundance. To illustrate, a needle-type air gap of 55-centimeter length will spark over at 200 kv whereas the sparking distance for a 12.5-centimeter sphere-type air gap at this voltage is only 17 centimeters.

F. W. Peek has shown ionizing potential gradients to occur at voltages in the order of one-tenth of those for which uniform electric field distributions obtain. In flight, if the electrified airplane surfaces are wet as they so often are from fog, clouds, or rain, these values may be reduced further by about one half. Even these reduced values are decreased still further because of lowered atmospheric pressure, the voltage being about halved at an altitude of 20,000 feet. Hence, threshold ionizing potential gradients lower than 31,000 volts per centimeter, in the order of 1,000 to 1,500 volts per centimeter, could be expected at the tips of wings, stabilizers, and propeller blades. In fact, the range of ionizing potential gradients, as anticipated by extrapolation from the results of Peek's classical experiments with conductors and spark gaps, is found to encompass those values actually measured on airplanes.

Table III. Ionizing Potentials of Constituent Gases of Air

Constituent Gases	Per Cent in Air by Weight	Ionizing Potentials in Volts
Nitrogen	75.5	14.52
Oxygen	23.2	13.60
Argon	0.3	15.73
Neon		21.53
Krypton		13.98
Xenon		12.11
Helium		24.54
Hydrogen		13.58

From "Handbook of Engineering Fundamentals," O. W. Eshbach, John Wiley and Sons, New York, N. Y., 1936, section 10, page 25.

CHARGING AND DISCHARGING CURRENTS

When an airplane first encounters precipitation static, the rate of rise of potential on it may be high, in the order of 200,000 volts or more per second; the relative potential, or the potential of the airplane above that of its surroundings, may rise quickly to a high value before the increasing discharge by air ionization finally levels off the potential to a constant value. At the afore-mentioned rate of rise of potential on a large airplane whose capacitance in flight, say, is of the order of 1,000 micromicrofarads, the charging current and, when equilibrium of potential has been attained, the discharging current both would be equal and of the order of 200 microamperes. Currents of four to five times this value are reported as having been measured on numerous test flights in airplanes.

When in low-level flight near a highly charged cloud, the difference of potential between wing tips readily may attain a value between 2,000,000 and 3,000,000 volts. Should the cloud discharge suddenly by a lightning stroke, perhaps within 100 microseconds, the electric charges of opposite polarity, previously held bound at the two wing tips but now free to neutralize each other, could pass several amperes of current through the intervening metallic wings. On huge aircraft of the dirigible class, the results of induced electrification are aggravated—not only because of the great length of these aircraft, but also because of their expansive areas upon which electric charges may accumulate. Under certain thunderstorm conditions, currents of large magnitudes have been reported to surge from end to end along the outer conductive covering and through the duralumin girders within.

RADIO AND ELECTRONIC CONTROLS ON AIRPLANES

Modern commercial aircraft, as well as the wide variety of military airplanes, not only are provided with radio communications, but also are equipped variously with radio navigational instruments whose several antennas, ranging from small dipoles to 40- or 50-foot wire types, are disposed about the outer surfaces of the

fuselage, wing, and empennage structures. These antennas pick up radiations from electrostatic spark discharges, and even are themselves a source of corona discharges. The result is obliteration or distortion of signals, sometimes lasting for hours. Radio equipment which may be employed on commercial aircraft is listed in Table IV, together with conventional orders of frequency and the common types and locations of associated antennas.

Of these radio devices, static interference with the company or command communication system is considered the most serious. The radio signal patterns which operate field approach instruments are generally strong enough near the airport to overpower interfering static noises. Radar is not affected appreciably by parasitic radiation from sparks on or about the airplane, because of its ultrahigh-frequency pulse operation. However, the radio beacon receiver, the frequency-modulation radio altimeter, and the radio compass finders may be affected by severe spark radiation and thus influence their indications of the space co-ordinates of the airplane position.

The widely-heralded new ground control approach (GCA) system by which radar operators at the airport spot on their "scopes" incoming airplanes several miles away and "talk" the pilots to ground obviously can be effective only if communication with the pilots is intelligible. Hence the success of GCA guidance of pilots while landing their airplanes under stormy conditions is especially dependent upon the use of highly effective antistatic means of eliminating radio interference.

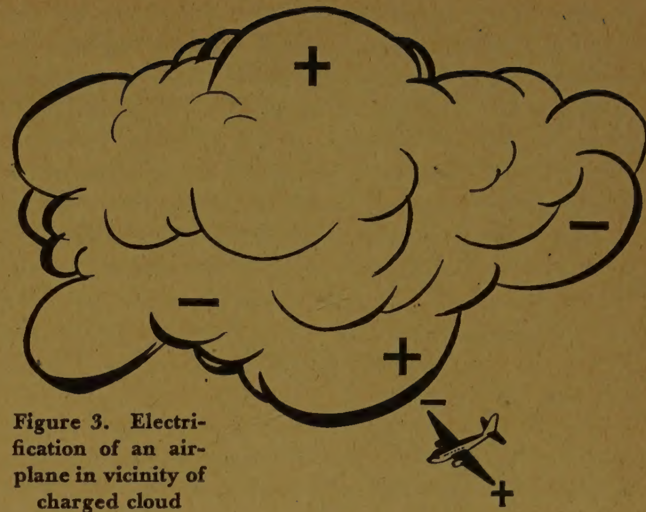


Figure 3. Electrification of an airplane in vicinity of charged cloud

THE CAUSE OF RADIO INTERFERENCE

It is regrettable, although understandable, that the literature on this subject has become confused and contradictory as to the basic conditions which cause radio interference on electrified aircraft. Corona discharge, known for centuries on shipboard as Saint Elmo's fire, long has been recognized as an electrical phenomenon, but it is only within the present decade that real headway has been made in understanding the basic mechanisms of corona—its complex underlying space-charge effects, field distortions, and ionic reactions. These studies have attained some degree of quantitative success through the aid of recently developed electronic instruments, and especially through the use of cathode-ray oscillographs. Even now less is known regarding negative corona than positive corona phenomena at point sources, and also, how the basic ionizing mechanisms of the two types differ. Furthermore the mechanisms underlying the various phases of corona discharge are radically different if the point source is an ordinary metallic blunt point or one of graduated sharpness.

Some recent papers state that radio interference arises as the result of corona discharges from parts of the electrified airplane or from improperly designed dissipators, without offering any clarification of basic conditions or recognizing refinements of terminology of the subject. Such statements completely lack necessary and essential definition, and obviously they are too broad and general for scientific recognition. If it were true that ionization, developing one or more aspects of corona discharge, caused radio interference under all circumstances and without restrictions or limitations as to contingent conditions, then, since ionization cannot be eliminated so long as high potentials exist, no cure could be anticipated for the electrostatic ills of airplanes except by applying cumbersome and costly methods of countergeneration for automatically eliminating electrification.

The author proposes to explain and correct some of these more glaring inaccuracies of statement and to show that, because of the erroneous thinking which prompted them, false premises have been established in prior attempts to mitigate radio interference. The proof of these incorrect concepts can be demonstrated, analytically, from certain scientific facts and, experimentally, from results of conclusive tests performed on conventional laboratory electrostatic equipment.

It has been long established that, when the potential on a charged member is raised to the threshold value at which ionizing potential gradients develop near sharp points, the free ions of the air, within the influence of these high field intensities, acquire sufficient energy to ionize by collision, or at least to highly excite, the neutral molecules of gases in the ambient air. Some of these newly formed ions, possessing opposite polarity to those on the charged member, are attracted strongly to the charged member, thus neutralizing an equal number of the resident electric charges and thereby constituting a d-c discharge. Other ions in the air recombine by recapturing electrons, and the number of such recombinations increases as a squared function[9] of the number of ions present of one polarity. Both the process of recombinations of ions and the readjustment

of electron energy levels within excited atoms liberate quantum units of energy called photons. These, by impinging upon other excited atoms, cause increasingly more photons to be ejected as well as more ionization to occur through the process of photoelectric emission. This form of emission is secondary to, or supplements and augments, ionization by collision. The electromagnetic energy thus radiated lies mostly in the ultraviolet and visible light spectra. As the intensity of the ultraviolet radiation and the visible light increases, the latter displays a violet haze at the sharper points and edges—the well-known phenomenon called visible corona or corona glow.

Even at the relatively low potential at which corona glow first may appear, the differentiating mechanisms of subsequent ionization behavior at the electrodes and within the interelectrode space display widely divergent characteristics, depending upon whether the point-to-plane electrode is energized positively or negatively and also upon whether the electrode possesses a relatively blunt point or a very sharp slender point. If the point is relatively blunt, increased potential gradients cause the formation of intermittent "burst corona"—a physical phenomenon discovered by Trichel and which engineers commonly call "streamers" or "leaders." In these, electron or positive-ion avalanches propagate at high velocity from the point electrode into the air gap space, cumulatively multiplying the space-charge growth, until they stop at varying distances out where the low field intensities become inadequate to self-sustain the propagation of the leader tips. Return avalanches variously neutralize the charges along these filamentary paths and then new ones originate which probe the same or other paths, forming as single or perhaps as stepped or forked leaders.

In substance, these leaders create tiny spatially formed sparks and their effect in shock exciting tuned radio circuits may be most severe indeed. Quoting from Loeb and Meek[10]

"Observations . . . indicate that sparks occur along very narrow filamentary channels even in their very early stages."

The volume density of ions within these leader filaments is of the order of from 10^{13} to 10^{14} ions per cubic centimeter wherein the radius of the filament is about 0.5×10^{-3} centimeters. The avalanche leaders develop in the amazingly short periods of from 10^{-7} to 10^{-8} second, and their velocity of travel up and down the filamentary channels is around 10^8 centimeters per second, being almost one per cent of the speed of light.

Quoting again from Loeb and Meek

"The streamers produce a large electrostatic disturbance and are capable of shock-exciting neighboring systems, owing to considerable values of di/dt of the order of 0.1 ampere per second. They cause the noisy corona discharge which is so troublesome in radio reception."

Table IV. Radio and Electronic Control Systems on Commercial Airplanes

Type of Control System	Frequency Band	Type and Location of Antennas
High frequency communication	2– 10 megacycles	Commonly on top from above pilot cabin to tip of rudder. From 35 to 50 feet long
Very high frequency communication	100– 150 megacycles	22-inch vertical mast on top of fuselage
Auxiliary approach control instrument landing system (ILS)	100– 156 megacycles	22-inch vertical stub, generally near top of pilot cabin
Localizer system (ILS)	100– 150 megacycles	Antler unit above pilot cabin
Glide path approach (ILS)	300– 340 megacycles	Dipole; part of mount on localizer antler antenna
Marker receiver (ILS)	75 megacycles	Wire antenna underneath fuselage, generally 75 inches long
Auxiliary beacon or range receiver	200– 500 kilocycles	Overhead or underneath wire or V pair from 10 to 15 feet long. Sometimes an overhead fin antenna is used additionally
Two automatic direction receivers	100–1,750 kilocycles	Two electrostatically shielded loops, generally under pilot cabin; each receiver may have its sense antenna either of the V type underneath or symmetrical T, generally in line
Radio altimeter, pulsed or frequency modulated	420– 460 megacycles	Two dipoles beneath fuselage
Radar system, pulsed	9,300–9,400 megacycles	Radome underneath pilot cabin or in nose of airplane

IONIZATION, CORONA GLOW, LEADERS, AND SPARKS

From the foregoing statements it is important to recognize that the various characteristic phases of corona discharge, ranging from the start of ionization to its culmination in spark-over, are determined by the gap geometry, the polarity of the point-to-plane electrode, the degree of sharpness of the point electrode, the space-charge distortion of the impressed field, the air pressure, and the potential gradients at the point. The forms of corona discharge result from the nature of the molecular breakdowns of the gas constituents of air by virtue of intensely localized fields at the metallic-point electrodes or fine wires.

At ionizing threshold potential gradients and regardless of polarity of the point electrode, the space charge within the gap volume, near the point-to-plane electrode, consists of ion products partly from ionization by collision and partly from secondary photoelectric emission in the air gases caused by photons originating from recombinations of ions and from collapsing energy levels in excited atoms. If the point is charged negatively, then in addition to these ion products, free electrons are released from the metal when its surface potential barrier is sufficiently weakened by increasing positive-ion bombardment from applied potential gradi-

ents of higher and higher voltage. Herein lies a basic difference in the ionizing properties of a metallic point when it is of negative as compared to positive polarity.

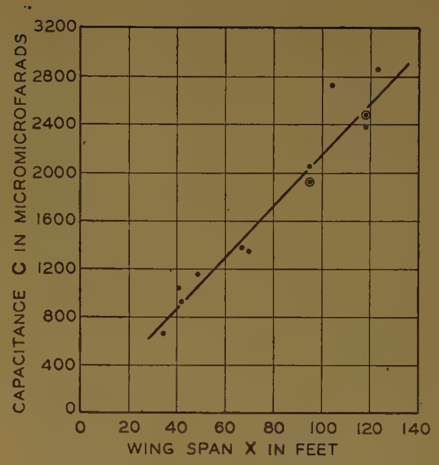
If the point is very sharp, corona appears at a lower potential when the point is of negative rather than of positive polarity. Also, when negatively energized such a point gives rise to more discharge current at the same potential than when positive. It has been determined by the author that a state of steady-glow corona at the tips of a multiple array of very sharp metallic points of negative polarity exists for a current range from 0.1 to 2.50 microamperes up to 110 to 170 microamperes for point-to-plane air gaps of 8-centimeter length down to one centimeter. Within this current range wherein steady-glow corona exists, the discharge is characterized by complete absence of radio noise up to explored frequencies of at least 165 megacycles. But, for higher potential gradients at which leaders are initiated, the disturbing current impulses which originate in them cause serious radio interference. When the sharp metallic points are given positive potential, they also discharge by steady-glow corona up to the potential levels at which leaders form, but the current range at which radio interference begins is somewhat less than for points with negative polarity.

From many tests made by the author, using multiple arrays of extremely sharp points, the current from negative discharge points was found to be roughly double that for the same voltage values from the points when positively polarized. All the different mechanisms by which ionization occurs at points and in the ambient air create ion multiplication in these high potential regions and, with increasing values of applied voltage, the current thereby increases at a more rapid rate than does the voltage. As demonstrated on a D'Arsonval microammeter, whose $5^1/_4$-inch scale contained low-current ranges of 0–10, 0–30, 0–100, and 0–300 microamperes, the direct current increases smoothly with rising voltage without the volt-ampere curves showing any indication of sudden transition from one stage of ionization and corona to another—that is, up to sparkover.

The criterion at which the transition from corona glow to the formation of leaders occurs in air is dependent upon the ratio of the potential gradient at the sharp-point electrode to the air pressure in millimeters, this critical ratio[10] at the transition being about 60. Hence at low atmospheric pressure the leaders and their incipient radio interference appear at reduced potentials.

If the point-to-plane electrode is blunt or even sharp but containing microscopic cavities, the corona properties have been found radically different than for a sharp smooth slender point. The blunt or rough point favors the early appearance of leaders with moderate potential gradients and, even at very low currents, the radio interference becomes[11] appreciable. Because of the complex configuration of the surface of a blunt point, the field

Figure 4. Measured values of capacitance to ground of airplanes versus wing span



Approximate values are given by the following formulas: On ground, $C_G = 21.3\,X$ *micromicrofarads*
In flight, $C_F = 6.70\,X$ *micromicrofarads* $= 0.315 C_G$

distribution over it is highly distorted and relatively intense at certain localities. Regardless of the polarity, the ionization mechanisms favor the formation of leaders. The space charge about blunt points may form and disappear with some semblance of rhythm[10] when embryonic leaders or burst-pulses originate. These sometimes result in musical tones or in howls from the radio receivers.

Each of these leader sparks, even the tiniest, gives spawn to a parasitic impulse of radiation which shock-excites any tuned radio receiver within the sphere of its influence. These shock excitations emerge from radio sets variously as a series of audible pops, clicks, and musical tones, or more commonly as howling, frying, sanding, and crashing noises. Their noise levels depend upon the intensity and rapidity of the parasitic signals and hence upon the lengths of the leaders and their rates of formation and decay.

Radio interference on airplanes during precipitation charging occurs whenever sparks are created—even the tiniest. The most minute sparks, as in embryonic ionized leaders, have a radiating power in air capable of energizing conventional receivers at distances of only some 8 to 10 feet. But even though such weak sparks occur at remote wing, stabilizer, or propeller blade tips, the impulses may be transmitted as a ground wave along the conductive airplane structure to the proximity of the antennas where they may induce appreciable radio interference.

Another insidious source of radio interference is that of creepage sparks occurring over insulators to bare antenna wires and over other insulated or unbonded parts on aircraft. These have been and still are especially prolific sources of parasitic disturbances to radio reception. Even the radiations from very weak creepage sparks at these locations may energize the adjacent antenna strongly. This intensive effect comes about by virtue of the conductive coupling of the antenna

Figure 5. Distribution of charges and areas where corona may appear on an airplane

directly to the source of the impulsive disturbance. The leakage of insulators is increased by the accumulations on them of dirt, oil, and soot, together with the hydrolyzing action of moisture. The electrostatic dissipators must be sufficiently effective dischargers to maintain the potential of the airplane well below the threshold of ionization for all burrs, antenna insulators, insulated members, and other parts of critical sharpness.

The use of polyethylene insulation on antenna wires and of polyethylene tape in covering the insulator bindings has been found helpful in reducing radio interference both from the insulator creepage sparks and the ionized leader sparks emanating from the otherwise bare antenna wires. Obviously, the maintenance of rigid service schedules in cleaning insulators, replacing them when necessary, and in renewing the tape is particularly important. Cycles of extreme temperature variations in flight sometimes cause polyethylene insulation to loosen from the antenna wire within, especially from the small-sized wire used on airplanes, thus leaving air voids between the wire and its covering. If the wire is permitted thereafter to ionize at these air voids, the insulation becomes weakened to the point of eventual puncture, thus reviving and even intensifying the problem of radio interference here where the insulation was applied essentially as the mitigating agency.

Tiny spark discharges across the surfaces of insulators on high voltage electric power lines at times have transmitted their shock impulses[12] over the wires throughout local areas for miles around, although in air they are attenuated to negligible values within 100 to 200 feet. This source of parasitic radiation caused such annoyance in radio reception within the affected areas that the persistent complaints of the residents eventually invoked state intervention through public service commissions on behalf of the distraught citizens. Many electric power companies now are conducting extensive research on the propagation of interference with radio reception by corona which originates on their high-voltage transmission lines. Present studies of corona effects in causing radio interference are largely in connection with airplanes passing near the lines or automobiles following the lines on nearby parallel highways.

DESIGN FEATURES IN RADIO NOISE CONTROL

The important conclusion presented here that sparks across insulators and ionized leaders from sharp points and edges on airplane structures are the essential causes of parasitic radiations which give rise to radio interference on airplanes—a conclusion based upon numerous types of experimental tests by the author—simplifies immeasurably the approach to the problem of designing effective controls for electrostatic radio disturbances.

At this stage in the thinking on design of a suitable electrostatic dissipator and in applying the theory of electric discharges at points, as already explained, two avenues of approach to the design problem are indicated. It must be decided whether

1. The electrostatic dissipator, by employing unsatisfactory ionizers and thus possessing relatively poor and insufficient dissipating properties which allow the potential on the airplane to rise to high levels, in consequence shall depend upon suppressing the shock impulses originating from the oscillatory currents in the burst-pulses of corona by using a built-in suppressive resistance of high ohmic value, and shall rely further upon the long air routes between it and the antennas to attenuate sufficiently the radiated impulses, or,

2. The device by using appropriately designed electrode points properly and adequately shall dissipate the electrification on the airplane without the generation of oscillatory corona discharges and without the use of undesirable and unnecessary impulse suppressors, keeping the current at each dissipator well within the threshold value at which noisy leaders form and, thereby, also maintaining the potential on the airplane at such a low level as to prevent the initiation of parasitic radio interference from any part of the airplane even under abnormal conditions.

Obviously the second method offers the more appealing, the more effective, and the safer criteria of design. It is this method which the author has employed and which will be described fully, including test data, in part II of this article.

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Grounding of Instrument Transformer Secondary Circuits

AN AIEE COMMITTEE REPORT

The inadequacies of certain methods of grounding of instrument transformer secondary circuits have been studied by the AIEE relay subcommittee. Multi- and single-point grounding have been considered both pro and con. Preferred practices for grounding these circuits are recommended by this subcommittee, which is composed of engineers who have had vast experience with the subject matter.

THE AIEE relay subcommittee has reviewed current practices and thoughts on grounding of instrument transformer secondary circuits for the purpose of disclosing shortcomings in certain methods and recommending preferred practices. Members of the working group were asked to

1. Outline briefly the practices followed in their organizations.

2. Describe any adverse experience that may have been encountered.

3. Present their opinions on the subject.

The information in their replies was summarized and copies of the findings sent to all members of the relay subcommittee, some of whom responded with additional suggestions. Where the term instrument transformer is used, it is intended to include both current and potential transformers. Following is a summary of the information received.

SUMMARY OF INFORMATION RECEIVED

General Opinions. Agreement was unanimous that instrument transformer secondary circuits should be grounded for safety of personnel and equipment; also that station ground copper should not be depended upon to complete any part of the secondary circuits of current transformers. Agreement was general that the latter principle should apply also to potential transformers but in the absence of adverse experience one company uses the station ground copper for this purpose except where long secondary runs to directional relays are involved.

Single Point and Multipoint Grounding. Single point grounding refers to the existence of only one ground connection on a secondary wiring system involving either a single instrument transformer, a set of transformers on a polyphase circuit, or interconnected sets of transformers such as may be used for differential relays. Multipoint grounding refers to the presence of two or more ground connections on such a secondary wiring system.

With the secondary circuit grounded at only one point, the secondary wiring does not parallel the station ground copper and run the risk of carrying a portion of the fault current which may cause incorrect relay operation or possibly burn off secondary wiring at some point. Where multigrounding is used there is also the risk that the ground relay may be shunted inadvertently through incorrect connection. Testing the secondary circuits with a megohmmeter to detect accidental grounds or deterioration of insulation is facilitated when the circuits can be isolated by removal of a single ground connection. This ground connection should not be removed while the instrument transformers are energized.

Experience. Operating companies with multigrounded instrument transformer installations reported isolated cases of trouble that were suspected of having been caused by the presence of more than one ground on a particular secondary circuit. The troubles were remedied by removing all but one ground from each circuit involved. As would be expected from the nature of the problem and confirmed by experience, relays in current circuits are to be influenced more likely by the effects of multigrounding than relays in potential circuits, because current relays will respond to smaller values of foreign potential that may be introduced into their circuits from multigrounding. Short-circuiting of a potential relay by incorrect application of several grounds will cause immediate fuse blowing whereas similar short-circuiting of a current relay may not be recognized at once. No experience was cited to show that single point grounding ever resulted in faulty operation of equipment or hazards to personnel that multigrounding would have prevented.

Practices Followed. Although it was admitted to be

Full text of paper **47-65**, "Grounding of Instrument Transformer Secondary Circuits," presented at the AIEE winter meeting, New York, N. Y., January 27–31, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

This report was prepared by a working group on grounding of instrument transformer secondary circuits of the relay subcommittee, AIEE committee on protective devices, consisting of **H. R. Paxson** (M '40, sponsor), senior engineer, inside plant section, electrical engineering division, Philadelphia Electric Co., Philadelphia, Pa.; **R. E. Cordray** (M '43), in charge of relay engineering, General Electric Co., Philadelphia, Pa.; **G. B. Dodds** (M '45), relay protection and section engineer, planning and development department, Duquesne Light Co., Pittsburgh, Pa.; **E. L. Harder** (M '41), central station engineer, Westinghouse Electric Corporation, East Pittsburgh, Pa.; **E. L. Michelson** (M '44), senior engineer, Commonwealth Edison Co., Chicago, Ill.; **K. N. Reardon** (M '45), switchgear engineer, West Penn Power Co., Pittsburgh, Pa.

theoretically desirable to ground the secondary circuits of instrument transformers at only one point irrespective of whether single sets of transformers or interconnected groups are involved, multigrounding has existed on some installations for many years without ill effect. On this basis several thought it unnecessary to change existing installations from multi- to single-point grounding where no adverse experience has been encountered but would recommend single-point grounding for new installations. One correspondent inferred that single-point grounding presents increased hazards, particularly to test men who may remove the ground connection.

Location of Single Ground Point. Considerable advantage is gained in operating and maintenance practices by placing grounds at points convenient for checking and removal when the secondary circuits are to be tested with a megohm-meter. The two preferred locations are at the instrument transformers or at the switchboard. Opinion, however, was divided on which to use because various reasons were advanced for each. It appears that no fixed rules can be applied, and decision must be based on local conditions for particular installations and individual preferences. Although many existing installations are grounded at the instrument transformer secondary terminals, the general trend is toward grounding at the switchboard. This is brought about probably by the greater use of relay schemes involving interconnected current transformers.

Advantages cited for grounding at the switchboard were

1. The ground is at a convenient point for checking or removal when the insulation of the secondary wiring is to be tested.

2. Greater safety is afforded personnel.

3. There is less likelihood of a ground connection being burnt off because of the failure of a current or potential transformer.

4. This is the preferred location for fault bus systems in order that the instrument ground will be remote from the fault bus ground.

5. Most comprehensive protection is provided for differential relay circuits because, electrically, the switchboard is centrally located with respect to the current transformer secondary wiring circuits.

One operating company with current transformer secondary circuits grounded at the switchboard prefers, where a ground relay is used, to ground the junction point of the phase leads before the common return passes through the ground relay. This practice is based on the theory that an accidental ground on any single secondary conductor will not render both the ground relay and a phase relay simultaneously inoperative. However, each current transformer secondary winding has the impedance of the phase relay or relays and instruments, when used, interposed between one end and ground and the impedance of the ground relay interposed between the other end and ground.

One switchboard manufacturer provides an instrument transformer ground on factory assembled switchboards at the switchboard for remote instrument transformers provided by the customer but recommends its removal if the secondary circuits are grounded elsewhere; final decision is left to the customer.

Where grounds are made at switchboards the ground connection should be placed in such a manner that it goes directly to a recognized ground bus and should not be looped about in such a way that any instrument transformer can be disconnected inadvertently from ground.

The principal reason advanced for placing the ground connection at the instrument transformer terminals was that in case of transformer failure, the fault current would not travel to the switchboard to reach ground. In some cases a ground at the instrument transformers facilitates checking the continuity of the common return wire which does not carry any current of fundamental frequency under normal load conditions.

Testing of Secondary Circuits. Attention was called to the fact that many so-called relay troubles are not relay troubles at all but result from troubles in the external circuits. Because faulty system operation may result from trouble in secondary circuits, it is important that they be tested periodically to detect open circuits, short circuits, accidental grounds, and deteriorated insulation. Testing the secondary circuits with a megohmmeter was recommended strongly; also the relay tester often can recognize faulty current transformer circuits by observing the difference in current required to operate each relay when it is isolated from the secondary circuit and again when it is connected to its current transformers; the current in the second case should be only slightly greater. There was one suggestion that periodic testing of secondary circuits be included as a definite recommendation.

CONCLUSIONS

The conclusions reached from the foregoing are embodied in the following recommended preferred practices:

1. The cases of instrument transformer always should be grounded.

2. The secondary circuit of a single instrument transformer, or that of a set of interconnected instrument transformers, always should be grounded and at only one location, that location to be either in close proximity to the instrument transformer secondary terminals or at the switchboard. When a neutral secondary wire exists, that wire preferably should be grounded.

3. Station ground copper should not be depended upon to complete any part of instrument transformer secondary circuits; the connection should be made always with an insulated wire.

4. When current transformers are mounted remote from the switchboard panel, and if they are to be grounded at the current transformers, a current transformer neutral ground bus should be used to which the neutral points of all current transformers in an interconnected group are connected. This bus should be grounded at only one point and should be a conductor as large or larger than the secondary phase conductors. It should be insulated

and connect all neutral points to a common ground in such a manner that the ground connection will not be removed unintentionally by the operation of any testing devices. The connection from the neutral bus to ground may or may not be insulated.

5. When instrument transformers are mounted back of the switchboard, the ground connection may be made to the panel ground bus. Ground connections for any transformer or set of transformers should not be made both at transformer ground bus and panel ground bus because of the possibility of difference in potential between the two ground busses as a result of the impedance of ground connections. This precaution is recommended primarily to assure accuracy of instruments and meters and correct performance of protective relays.

6. Certain types of secondary circuit interconnections, such as for current totalizing or differential relaying, should have their ground connection preferably at the switchboard panel. Delta-connected current transformers used in conjunction with Y-connected current transformers to supply transformer differential protection are grounded through the coils of the differential relays to the neutral of the Y-connected transformers.

7. To minimize the possibility of secondary circuit trouble interfering with the performance of instruments, meters, and relays, the instrument transformers and their secondary circuits should be tested at periodic intervals for short circuits, open circuits, accidental grounds, and deterioration of insulation.

Fractional-Horsepower Motor Standards

C. P. POTTER
FELLOW AIEE

The National Electrical Manufacturers Association, a nonprofit trade association supported by manufacturers of electric equipment, has developed a standardization plan for fractional-horsepower motors (EE, Nov '46, p 541). The purpose of the new standards is to improve the quality, reliability, and life of small-power motors.

THE National Electrical Manufacturers Association motor and generator standards defines a small-power motor as one "built in a frame smaller than that having a continuous rating of 1 horsepower, open type, at 1,700–1,800 rpm." Small-power motors are more familiarly known as fractional-horsepower motors, and for all practical purposes, fractional-horsepower motors are those which are included in the range from 1/20 to 3/4 horsepower, inclusive. The new fractional-horsepower motor standards which we propose to discuss are those which recently have been adopted by NEMA and are entitled, "Definition of Motor Output" and "Service Factor."

The general public depends more than it realizes on the successful operation of fractional-horsepower motors. There are millions of these motors in operation in the United States at the present time, and the public has become accustomed to having them operate night and day with few interruptions. This indicates that the motor manufacturers have done a good job in producing reliable motors and motors which have good operating performance.

Every fractional-horsepower motor has a horsepower rating stamped on its name plate and this should be a definite indication of its capabilities. However, motor characteristics are frequently modified to suit the desires of the manufacturer of the devices which they operate. Some of these modifications are logical, some of them are not.

An open-type fractional-horsepower motor (and most of them are open type), with good operating characteristics, usually has a temperature rise somewhat less than 40 degrees centigrade. Manufacturers of motor-driven devices which are used in highly competitive fields, have found this out, and have applied these motors so that they carry considerable overloads. When this is done, it is necessary to increase the starting torque and breakdown torque of these motors so that if operating conditions should become abnormal, or if the voltage should become low on the customer's premises, the motor will operate in spite of these handicaps. There have been

Essentially full text of paper 47-93, "New NEMA Fractional-Horsepower Motor Standards—Their Effect on Refrigeration and Pump Applications," presented at the AIEE winter meeting, New York, N. Y., January 27–31, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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Table I. Motor Rating

Small-power single-phase induction motors shall be rated primarily on the basis of breakdown torque. The value of breakdown torque for the purpose of defining horsepower rating shall fall within the indicated ranges

RPM		Brake Horsepower Rating								
		1/20	1/12	1/8	1/6	1/4	1/3	1/2	3/4	1
Synchronous RPM	Approximate Full Load RPM	Breakdown Torque,* Ounce-Feet								
3,600	3,450	2.0– 3.7	3.7– 6.0	6.0– 8.7	8.7–11.5	11.5–16.5	16.5–21.5	21.5–31.5	31.5–44.0	44.0–58.0
3,000	2,850	2.4– 4.4	4.4– 7.2	7.2–10.5	10.5–13.8	13.8–19.8	19.8–25.8	25.8–37.8	37.8–53.0	53.0–69.5
1,800	1,725	4.0– 7.1	7.1–11.5	11.5–16.5	16.5–21.5	21.5–31.5	31.5–40.5	40.5–58.0	58.0–82.5	
1,500	1,425	4.8– 8.5	8.5–13.8	13.8–19.8	19.8–25.8	25.8–37.8	37.8–48.5	48.5–69.5	69.5–99.0	
1,200	1,140	6.0–10.4	10.4–16.5	16.5–24.1	24.1–31.5	31.5–44.0	44.0–58.0	58.0–82.5		
900	850	8.0–13.5	13.5–21.5	21.5–31.5	31.5–40.5	40.5–58.0	58.0–77.0			

* Breakdown torque range includes the higher figure down to, but not including, the lower figure.

Table II. Service Factors

Horsepower	Service Factor for General Purpose 40 C Induction Motors
1/20	1.4
1/12	1.4
1/8	1.4
1/6	1.35
1/4	1.35
1/3	1.35
1/2	1.25
3/4	1.25
1 (at 3,600 rpm only)	1.25

The temperature rise on which the name plate rating is based shall be no more than 40 degrees centigrade for all coil windings. When authorized by the manufacturer such a motor may be operated (at rated voltage and frequency and in an ambient temperature not exceeding 40 degrees centigrade) at a continuous load greater than rated load determined by the above service factors. It is recommended that the service factor shall be marked on the name plate in addition to the rating.

instances where this practice has been carried too far, with the result that some of these fractional-horsepower motors do not have the life expectancy which they would have if they were more conservatively designed and applied. Unfortunately, NEMA standards have not been sufficiently definite on the subjects of fractional - horsepower torque and overload, and the reason for adopting the two new NEMA standards is to promote a more logical design and application of fractional-horsepower motors so as to serve the best interest of all parties concerned.

BREAKDOWN TORQUES

As indicated previously, the breakdown torques of single-phase fractional-horsepower motors have varied considerably depending upon customers' requirements. As a result a motor obtained from one manufacturer might be perfectly satisfactory for a given application, while a motor of the same type and horsepower rating furnished by another manufacturer might be entirely unsuitable. This has made it necessary for purchasers to test each manufacturer's motor on his device before he can be sure that it will do the job. In order to correct this difficulty, NEMA has defined single-phase fractional-horsepower motors in terms of breakdown torque as shown in Table I. This table allows every purchaser to determine the breakdown torques he may expect to obtain when buying motors of a given horsepower rating from any motor manufacturer and provides a definite basis for applying them.

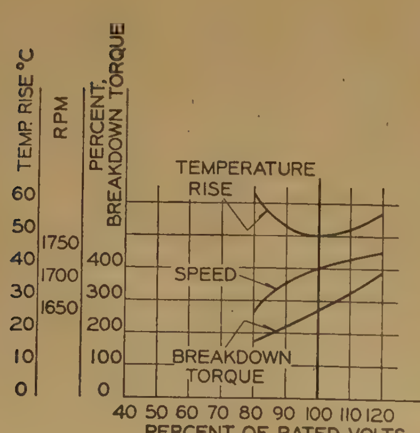

Figure 1. Effect of abnormal line voltage on temperature rise, speed, and breakdown torque of a typical 1/3-horsepower single-phase 60-cycle 1,725-rpm motor operating at 135 per cent rated load at rated voltage

SERVICE FACTORS

Service factor is a number by which the horsepower rating should be multiplied in order to determine the maximum safe load which may be applied to the motor. The service factors for fractional-horsepower single-phase motors which have been recently adopted, are given in Table II. These service factors were obtained by determining the overloads which produce a 50 degrees centigrade rise on motors having an actual temperature rise at full load of 40 degrees centigrade, and are intended to be used only where the voltage and frequency are held within close limits and where the ambient temperature does not exceed 40 degrees centigrade.

REASONS FOR CHOICE

The statement has been made that an open-type fractional-horsepower motor with good operating characteristics may have a temperature rise somewhat less than 40 degrees centigrade. The service factors were determined by assuming that the temperature rise at full load is 40 degrees centigrade. It is quite obvious, therefore, that the use of the service factor may not absorb all of the thermal capacity of the motor, or in other words, it may be possible to use still higher overloads on certain applications without damage to the motor. There are several reasons for the choice of such conserva-

tive factors. These reasons are enumerated in the following:

1. It is felt that a factor of safety should be allowed to take care of low-voltage abnormal operating conditions and high ambient temperatures. Electrically driven devices which have wide distribution are quite likely to be installed in rural communities where the voltage conditions may be bad, and where the cost of servicing these devices may be very high. It, therefore, seems to be economically sound to choose service factors which give the motor manufacturer, the machinery manufacturer, and the user a chance to operate successfully under adverse conditions. Figure 1 shows the effect of voltage variation on the temperature rise of a typical fractional-horsepower motor. This indicates quite clearly that a motor which will operate satisfactorily at a reasonable overload and at normal voltage may have a dangerous temperature rise under abnormal voltage conditions.

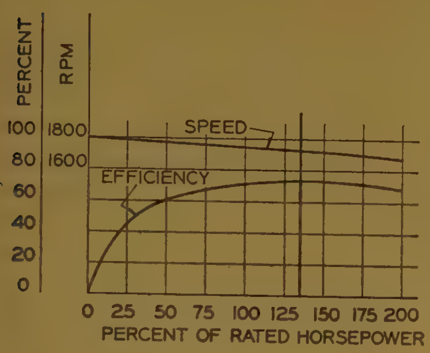

Figure 2. Speed and efficiency plotted as a function of per cent rated horsepower of a typical 1/3-horsepower single-phase 60-cycle 1,725-rpm motor

2. The maximum efficiency of single-phase motors occurs approximately at the overload allowed by these service factors. If, therefore, the machinery manufacturer is interested in obtaining the best possible over-all efficiency, it will be to his advantage to operate the motor at these service factors. Figure 2 shows a typical performance curve for a 1/3-horsepower single-phase motor which now has a service factor of 1.35. It will be noted that the maximum efficiency occurs at 135 per cent of full load, and that the speed of the motor at this load is still quite high.

3. When excessive overloads are applied to any single-phase motor, the speed of the motor decreases considerably, and this affects the operation of the driven machines. For example, if the speed of a motor driving a refrigeration compressor or pump drops too much, the output may be reduced to a point which makes it unsatisfactory to the user.

4. There is a definite relationship between breakdown torque and locked current. There is a growing tendency on the part of power companies to limit the applications of motors on the basis of locked current rather than on the basis of horsepower rating. Motors with greater service factors must have more breakdown torque, resulting in higher locked currents, and it is possible that these currents sometime may cause trouble by failing to meet the requirements of the local power companies.

LOCKED ROTOR CURRENTS

The maximum values of locked rotor currents for single phase motors have been standardized and are shown in Table III. Motors of 1/2 and 3/4 horsepower have had code letters stamped on their name plates for several years, and in the near future motors smaller than 1/2 horsepower also will have the code letters stamped on the name plate. The code letters are determined from Table IV. It is evident that motors with code letters at the beginning of the alphabet have lower locked currents than those toward the middle or end of the alphabet.

EFFECT OF STANDARDS

A manufacturer of refrigeration equipment or pumps may agree with all of these statements and at the same time may feel that the new NEMA standards will cause a great deal of expense and inconvenience and may make it necessary to use larger and more expensive motors for driving the same equipment. The new NEMA standards do not require any changes in the performance or capacity of motors which have been established on their applications and which are giving good service. The standards provide a consistent method of designating the rating of such motors without making any changes in the motors except perhaps the horsepower stamping on the name plate.

It is quite unlikely that any motor user will be required to make any changes in the applications of motors which have been applied on a sound basis and whose life has been satisfactory. In cases where the user is buying motors which have greater breakdown torques than those covered by NEMA standards, it will be necessary, after a suitable period of time, to stamp the name plates of these motors properly. Certainly, all new applications should be made on the basis of the new NEMA standards and if this is done, then the following results will be obtained:

Table III. Currents

Rated Horsepower	Locked Rotor Current Amperes 115 Volts	230 Volts
1/6 (and smaller)	20	10
1/4	23	11.5
1/3	31	15.5
1/2	45	22.5
3/4	61	30.5

Table IV. Coding

Code Letter	Kva Per Horsepower*
A	0 – 3.15
B	3.15– 3.55
C	3.55– 4.0
D	4.0 – 4.5
E	4.5 – 5.0
F	5.0 – 5.6
G	5.6 – 6.3
H	6.3 – 7.1
J	7.1 – 8.0
K	8.0 – 9.0
L	9.0 –10.0
M	10.0 –11.2
N	11.2 –12.5
P	12.5 –14.0
R	14.0 –and up

* Locked kva per horsepower includes the lower figure, up to but not including the higher figure.

1. The user will be supplied with motors which have a long life and which will not cause losses due to fire or stoppage of production.

2. The application engineer and the appliance manufacturer will be able to select the proper motor without having to test each application.

3. The power companies will be able to connect these motors to their circuits, and feel sure that their equipment is adequate and that the operation of the motors will not cause annoyance to their customers.

The Shortage of Engineers

A Problem for Education and Industry

HENRY T. HEALD

The present acute shortage of engineers caused by the United States' selective service policy during World War II is currently of much concern to the profession. Although it is probable that it will be at least five years before the condition is corrected, the situation can be alleviated somewhat by intelligent co-operation among the main competitors for the available supply of qualified engineers—industry, research, and education.

A WIDE AREA is covered by the field of electronics. Production, applied research, fundamental research, and education have joined together to pool their resources for the accomplishment of objectives not likely to be achieved without the aids of each other. However, there are some critical problems that are of vital interest to every industry, every college, and every research laboratory represented in the field. That they are not technical in no way minimizes their importance.

THE PROBLEM

First, there is the problem of qualified engineering and scientific personnel. All of us are familiar with the current shortage of qualified scientists and engineers. A recent study by the American Society for Engineering Education predicts that it will be 1952 before the supply of engineering graduates is again equal to the demand, in spite of the fact that the country's engineering colleges are now enrolling more students than ever before. A similar condition exists in physics, chemistry, and other sciences. It is futile now to condemn those in the government who ill-advisedly dissipated the supply of future scientists and engineers by sending them into the Armed Forces. The fact remains that this was done—the resulting problem is now ours.

Industry, education, and research must rely almost entirely on university trained scientists for teaching, for research, and for technical development. Obviously industry, the research laboratories, and the educational institutions now are competing and will continue to compete for trained personnel. This is the logical result of the condition in which we find ourselves. I shall not be so naive as to suggest that this situation can be changed. However, I am convinced that it can be alleviated to some extent by intelligent co-operative planning and action. In the first place, the universities are the source of our trained scientists. If qualified teachers and investigators are siphoned off into industry, how then are we to train adequate scientific personnel for industry and industrial research? We must be careful lest we repeat the mistake made by Selective Service which now is causing so much concern. It may be trite, but it is still an instance of the goose that laid the golden eggs. A good college professor is generally more than a teacher. He has those rare qualities of character and leadership which draw students to him and to his subject. When such a man has to leave the academic field to earn a more adequate living, not only are the students and the university the losers, but industry is also the loser in the long run because it is depending on him to recruit and train its future technical and research workers. For self-protection industry has a stake in seeing that university professorships are made equally attractive to those postions outside of the university class room and laboratory.

At the same time, the universities have a very definite obligation to industry in its effort to secure properly qualified personnel. Certainly many progressive universities have inaugurated programs designed to meet this problem. At the Illinois Institute of Technology a plan of optional curricula in the fourth year has been adopted which provides three programs: one emphasizing the conventional scientific and technological studies; another designed to provide better preparation in the fields of production and operation of industry; and the third for those interested in research and highly creative professional activities, frequently leading to graduate work. Progressive industries are not overlooking the fact that there are a number of ways to provide upgrading for their own employees through co-operation with educational institutions. Many are creating graduate fellowships to assure themselves of adequately trained personnel. Co-operative courses are a means of providing a continuous supply of engineers. Part time graduate and undergraduate programs, in many instances leading to a degree, are being given in the principal metropolitan centers. Some institutions are providing in-plant training programs on both graduate

Essentially full text of an address at the National Electronics Conference, Chicago, Ill., October 3, 1946.

Henry T. Heald is president, Illinois Institute of Technology, Chicago, Ill.

and undergraduate levels. Courses designed to meet special needs like the seminar just started at the Illinois Institute of Technology, "Management of Research," can be arranged. These are only a few of the ways in which the colleges are helping industry to meet the need for technically trained personnel. Most of these services are equally available to the small industry and to the large one.

THE TRIANGLE OF SCIENTIFIC PROGRESS

If education is the base of the triangle of scientific progress, certainly fundamental research and applied research are the two legs, each of which is essential to the support of the other. The late Doctor Thomas Midgley, Jr., when president of the American Chemical Society, pointed out the difference between fundamental and applied research in these words:

> ". . . .we need to increase our knowledge of the universe in which we live. The only fundamental tool at our command for extending this knowledge is the reproducible experiment. This is the accepted scientific method, and when applied to obtain a better understanding of our environment is designated by such terms as fundamental research, pure science research, or academic research. Once new facts about our environment are discovered, we can make use of these new facts to alter or control our environment to some extent. The process of applying the facts, determined by fundamental research, to a better control of our environment is called applied research or development work or invention."

If Doctor Midgley's statement is accurate, and I believe it is, then one of our chief concerns must be freedom of inquiry and the development of our facilities for pure scientific research, for without this reservoir of fundamental knowledge about our environment the pipe lines of industrial research soon will dry up. This is a problem in which industry and education must join to find a solution.

THE PROFIT MOTIVE

I already have referred to the problem of scientifically trained personnel, a lack of which seriously will handicap the progress of both fundamental and applied research. With increased emphasis on research in industry, there is the danger that industrial research will outstrip progress in the fields of fundamental investigation. If this happens, it will not be because university scientists have exhausted the possibilities of discovery. It will be because there are not enough of them or not sufficient funds to do the job. Industrial research works primarily from the profit motive. As a matter of fact, this has been largely the reason why the benefits of science have been made available to all. Pure research with a few exceptions is financed through grants or endowment. Today the field of research is so comprehensive, the demand so great, that universities no longer can depend entirely on the grants of educational foundations and their own endowment funds, most of which are designated for educational purposes. As M. L. Tainter, director of research for the Winthrop Chemical Company, says:

> "Development of new fundamental knowledge cannot be maintained at adequately increasing rates if university research does not accelerate with the industry which it feeds. For this the universities need more income."

The universities have only two sources of additional income. Private industry, their partners in free enterprise and research, or the government. State controlled research is not always accompanied by freedom of inquiry. Universities desire to control their own programs of fundamental research because freedom is the soul of research. Private enterprise can be served best by sustaining the institutions which give it life. It is not yet too late for industry, and by industry I mean individual corporations large and small, to arise to their responsibilities. But there are signs that the time is short.

Fundamental knowledge belongs to all men—it is the heritage of future generations. At the same time, it is doubtful whether the benefits of pure science would have been distributed so widely if it were not for the profit motive which spurs individuals, or, more often now, teams of individuals to invention and practical application of fundamental principles. I do not defend the profit motive on the ground that it is a part of the American way of life and therefore a sacred symbol. Our democratic civilization is a dynamic one—we are used to change. If the profit motive does not work, it should be eliminated. But the fact is that it does work—and it is only when we overload it as we did in 1929, or slow it up by ineptitude as we are doing today, that it fails.

There are those who believe that research in the physical sciences and engineering should be stopped for some indefinite period until the humanities catch up. There are others who would place industrial research under government control. Some propose that we change our patent system so that a man's ingenuity and inventiveness has no marketable value. It is not the fault of science that social thinking, international relations, and human conduct have not kept pace with man's progress in the physical sciences. The fact is, in the field of science, man has depended on a method of arriving at the truth from facts and not from attitudes and emotions. Industrial research must continue as a ward of the scientific method and not of governmental administration. And certainly the labor of the inventive mind should have its compensation as does the labor in other fields. The solution of many of our problems will not be found in subjecting science and research to the rather uncertain control of political agencies. Rather, our hope lies in bringing the methods of scientific thinking to bear on our political and economic problems that we may achieve the success in our social structure that we have in the sciences.

The Improved PCC Car

S. B. COOPER

The PCC streetcar is a result of a co-operative research program started in 1929 by the "Electric Railway Presidents' Conference Committee." The committee was formed because rising costs and declining revenues demanded standardization so that mass production of cars and their equipment could effect lower prices and higher quality.

THE number of PCC (Presidents' Conference Committee) cars in service and on order is the best possible testimonial to their success. This success is quite impressive when it is recalled that the period covered includes the latter years of the depression and the war years with material and production restrictions.

There is still much transit rehabilitation work to be done. Undoubtedly many existing car lines in smaller cities or secondary and cross-town lines in the larger cities will be changed over to trolley-coach or motor-coach operation. The modern streetcar, however, remains a most efficient vehicle for heavy trunk-route service in the large cities, a field where density of riding is too high for a 40- or 44-passenger vehicle and not high enough to justify real rapid transit subways. There is growing recognition of the fact that street congestion is largely a function of the number of vehicles, and attempting to handle large numbers of people in private automobiles or in small capacity transit vehicles is neither efficient nor economical. City planners now recognize the prime importance of mass transportation in our cities. Along with plans for freeways and super highways, consideration is being given to the needs of the great number of people who necessarily will continue to depend on public transit. In a number of instances, plans are being studied for rail rapid transit in conjunction with the freeways with stations arranged for convenient interchange with feeder lines for local distribution.

The PCC car equipment already has been developed for multiple unit operation, first for the Pacific Electric Railway in Los Angeles, Calif., and later for the Boston Elevated system. The Chicago Rapid Transit system has on order four experimental articulated cars of PCC type modified for their service, and the development of larger capacity trucks and equipment to apply the basic ideas of the PCC to heavy service is under way. Foreign cities are showing considerable interest in this type of car, and it may be expected that many cars of this type will be used abroad.

Future developments probably will trend toward weight reduction by the use of lighter metals, continuing effort for greater passenger comfort and appeal, and for simplification and further reduction of maintenance and inspection work.

The results obtained certainly bear out the hopes and expectation at the start of the committee's program. The cars have shown great passenger appeal and have met with almost unanimous public approval. The advantages of standardized design of body trucks and equipment, permitting minor modifications without too great change in major tooling, have been obvious. To be sure, costs have risen sharply, but so have all costs, and it is certain that even at today's costs, the industry is obtaining cars at much lower prices than would have prevailed under the old system of small individual lots.

The PCC car has justified the time, effort, and money spent on its development and has established itself as an efficient and attractive vehicle for the transit industry.

The first PCC cars were ordered early in 1935, and during the years from then until 1944, about 2,500 cars were placed in service on 16 properties in the United States and Canada. It was recognized that following the war, there would be an increased demand for equipment to replace older rolling stock worn out by intensive use during the war period. A program was started to review and evaluate the experience with the cars up to that time, and to establish the objectives of further developments and improvements to be incorporated in the postwar designs. This program resulted in the production of a sample 1945-model car which was placed in service on the Pittsburgh Railways Company lines in October 1945.

Figure 1. The first postwar model of the PCC car

Essentially full text of paper 47-41, "Some Recent Developments in the PCC Car," presented at the AIEE winter meeting, New York, N. Y., January 27–31, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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IMPROVEMENTS

Body changes were made to improve passenger comfort and aisle width by making seat spacing and post spacing the same. This makes it possible to move the seat cushion closer to the side wall of the car and to obtain a greater effective aisle width. Standee windows now have been adopted as a standard feature, making it possible for the standing passengers to see out without stooping.

The slope of the windshield has been increased and this, together with improvements in the "shadow apron" over the operator's desk, greatly reduces windshield reflections and improves the operator's view of the street at night. The shape and location of the front corner posts have been altered so as to minimize the "blind spots" and increase safety. The operator's position has been raised and moved forward somewhat to give him a better view of the area immediately in front of the dashboard. Detail improvements in doors and door mechanisms facilitate entrance and exit.

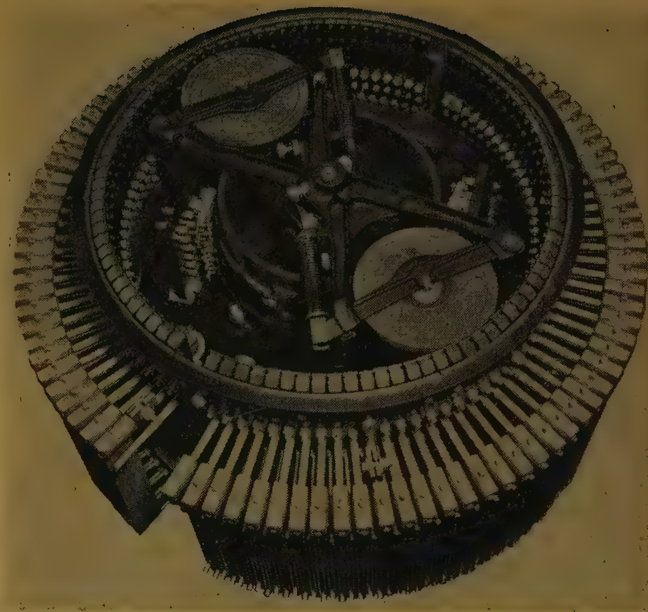


Figure 2. The accelerator as viewed from below

Table I. PCC Cars in North America as of November 1946

Transit Company	Total Number	On Order	In Operation
Baltimore Transit Company, Baltimore, Md.	275		275
Birmingham Electric Company, Birmingham, Ala.	48	48	0
Boston Elevated Railway, Boston, Mass.	271	21	250
Chicago Surface Lines, Chicago, Ill.	683	600	83
Cincinnati Street Railway Company, Cincinnati, Ohio	53	25	28
Cleveland Transit System, Cleveland, Ohio	50	50	0
City of Shaker Heights, Department of Transportation, Cleveland, Ohio	25	25	0
Dallas Railway and Terminal Company, Dallas, Tex.	25	0	25
Department of Street Railways, Detroit, Mich.	80	78	2
ohnstown Traction Company, Johnstown, Pa.	17	17	0
Kansas City Public Service Company, Kansas City, Mo.	99	41	58
Los Angeles Railway Corporation, Los Angeles, Calif.	165	40	125
Louisville Railway Company, Louisville, Ky.	25	25	0
Twin City Rapid Transit Company, Minneapolis, Minn.	91	90	1
Mexico City Tramways, Mexico, Federal District, Mexico	1	1	0
Montreal Tramways, Ltd., Montreal, Quebec, Canada	18	0	18
New York City Transit System, Brooklyn, N. Y.	100		100
Pacific Electric Railway, Los Angeles, Calif.	30		30
Philadelphia Transportation Company, Philadelphia, Pa.	470	210	260
Pittsburgh Railways System, Pittsburgh, Pa.	566		566
St. Louis Public Service Company, St. Louis, Mo.	300	100	200
San Diego Electric Railway Company, San Diego, Calif.	28		28
San Francisco Municipal Railways, San Francisco, Calif.	15	10	5
Capital Transit Company, Washington, D. C.	489		489
Toronto Transportation Commission, Toronto, Ontario, Canada	390	100	290
British Columbia Electric Railway Co., Vancouver, British Columbia, Canada	36		36
Total	4,350	1,481	2,869

Heating and Ventilating. In spite of the fact that the original PCC car had a system of ventilation that took 1,200 to 1,500 cubic feet of air per minute out of the car, it has been recognized for some time that further improvement in car ventilation was desirable. It was felt that a definite circulation of additional fresh air would add materially to passenger comfort.

As the result of a considerable amount of experimental development, a system of ceiling ventilation now is available as an optional feature. A longitudinal roof monitor with louvered sides extends almost the entire length of the car roof. This is divided by cross barriers into alternate intake and exhaust sections. Three or four vertical motor-driven fans, spaced along the ceiling of the car, draw their air from the intake sections of the roof monitor and discharge it directly into the car through diffusion grilles. These grilles are arranged so as to direct the air flow out along the ceiling line and downwards diagonally and along the sides of the car to give a definite feeling of air movement but without direct blast or draft effect. The roof monitor and fan intakes are designed to trap and drain moisture. The space between the ceiling and the car roof is used as an exhaust duct communicating with the outlet sections of the monitor. The fan motors are connected in series across the line and are arranged for thermostatic control of fan speed—the speed being increased with higher outdoor temperatures. At top speeds these fans introduce a total of 12,000 to 14,000 cubic feet of fresh air per minute into the car. Experience with this system indicates that it may be possible to operate with permanently closed windows.

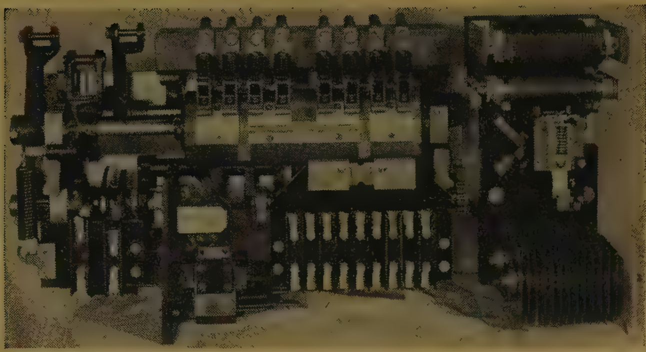


Figure 3. The combined master and brake controller

This ventilation system has brought with it a change in the motor-generator-blower system of equipment ventilation and car heating. The air exhausted from the car by the motor-generator blower now is drawn partly through air intake grilles in the side lining of the car in the area opposite the center doors and immediately above the motor-generator-blower compartment, and partly from the center door step-well through the space between the car floor and the accelerator support plate. The motor-generator set now has a blower on each end. Each of these two blowers has its runner and housing partitioned by a divider plate, giving in effect two sections to each blower. In each one, the outer section furthest from the motor-generator set draws its air through louvered openings in the outside of the car and discharges it into a duct under the car floor leading to the two traction motors on the adjacent truck.

The inner section of each blower draws its air from the car body through the paths described above, and discharges it directly into the equipment compartment over the accelerating and braking resistors. From this space it is blown into cross ducts just ahead and back of the step-well section, and then directed by the thermostatically controlled dampers either to outside air in nonheating season or to the longitudinal sill ducts on both sides of the car in the heating season.

Because in summer weather the car body is under pressure ventilation from the ceiling fans, the side sill heater ducts also serve as air outlets from the car, further improving body ventilation and avoiding any possibility of damper leakage permitting warm air entering the car from the equipment.

Auxiliary heaters are mounted in the air stream on the outlet side of the blowers, so that in case of a blockade or in case of infrequent stop service where acceleration or braking resistor losses are insufficient to maintain comfortable car temperature, these auxiliary heaters are automatically cut in.

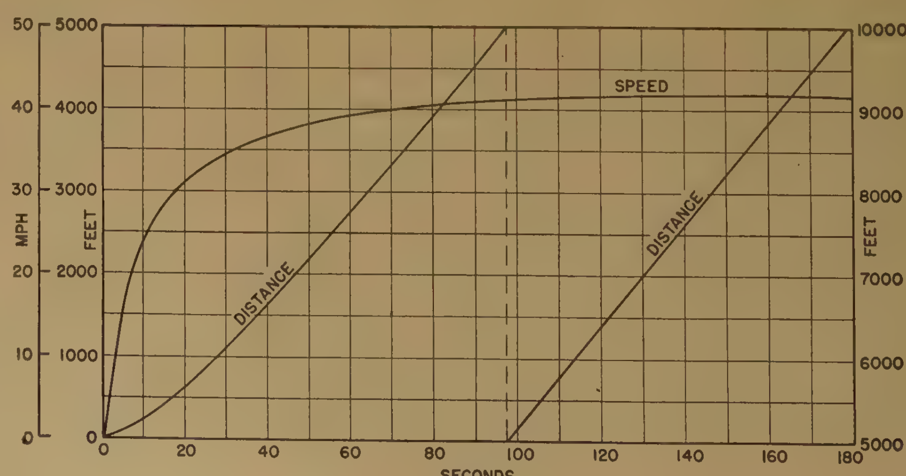
Braking. Important improvements have been made in braking. The cost, complication, and maintenance of the air brake system seemed out of line with the small amount of work required for completion of the stop below the speed of dynamic fade-out, and for holding the car at stops. In addition, it had proved quite difficult to keep the brake levers and shoes of the air-operated wheel brakes from accumulating clearances from wear and consequent noise and rattles. These reasons led to investigation of other forms of supplementary mechanical brakes. In 1939 the St. Louis Public Service Company purchased 100 cars of the "all-electric" type. The performance of these and of the second hundred purchased in 1941 was so successful that the initial skepticism of the industry was overcome and all-electric operation now has been adopted as standard.

On this type of car the air-operated shoe brakes bearing on the wheel tread have been replaced by drum brakes carried on the coupling at the motor end of the drive shaft. Two forms of brake are in current production and use—an internal expanding and an external contracting. In either case, either of two forms of operating mechanism can be used—spring application and solenoid release; or solenoid application and spring release, with special means provided for spring application

* The Davis formula for train resistance may be found in standard engineering handbooks. Mechanical Engineers' Handbook, Lionel S. Marks. McGraw-Hill Book Company, New York, N. Y., page 1494.

Figure 4. Speed, time, and distance performance curves

Weight of empty car, pounds......36,000
Average passenger load, pounds......6,000
Equivalent rotational allowance, pounds......5,600
Motors per car......4
Motor type......1432-J
Gear ratio......7.17 to 1
Wheel diameter, inches......25
Accelerating rate, miles per hour per second......3.5
Average voltage......550
Train resistance....Davis formula plus 6 pounds per ton*
Grade and curve resistance......0



in case of failure of control power. This makes it possible to do away with the former hand brake for parking the car in sidings or yards.

The desirability of increasing the emergency reliability of the drum break led to the development of extended dynamic braking at speeds as low as one mile per hour. This development was carried out with the co-operation of the engineers and staff of the Pittsburgh Railways Company and has proved remarkably successful. This limits the normal duty on the drum brake almost entirely to holding at stops, and therefore reduces the wear on shoes and drums to a point within the practical limits of a short travel device like a solenoid.

Improvement also has been made in the "easy shut-off" by introducing resistance into the circuit before opening the line switch. This feature adds materially to passenger comfort during "on and off" operation behind slow traffic or with the nervous operator who, in spite of training and instruction to the contrary, will start and shut off two or three times while waiting for the traffic light to change.

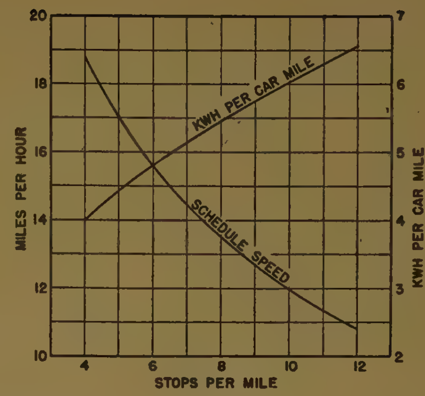
A combined master and braking controller simplifies installation and maintenance by providing permanent line up between the limit relay and the cams on the power and brake controllers.

Circuit Breakers. The trend at present is toward the use of De-ion type circuit breakers in place of fuses for both 32-volt and 600-volt circuits. A trip is indicated by the position of the handle, making it easier for the operator to quickly locate the circuit in trouble. Pushing the handle to "off" then to "on" is easier and quicker than hunting for and replacing fuses.

Motor Ventilation. The necessity for finding room for the brake drum at the drive end of the motor was what first necessitated forced motor ventilation. The traction motor was shortened by omitting its internal ventilating fan. Since that time, the obvious advantages of forced motor ventilation have become more generally recognized, and it, no doubt, would be continued today for its own merits entirely aside from the question of brake drum space. Forced ventilation keeps the motor under pressure, thus tending to keep dirt and water out rather than sucking them in as under natural ventilation. The uniform continuous flow of cooling air independent of speed has proved much more effective than the widely fluctuating amount of air resulting from the internal fan at varying speeds.

Figure 6. Surface car operating characteristic

Same car as described in Figure 4



Braking, miles per hour per second 3.15
Grade resistance .... 5 pounds per ton
Coasting .... 25 per cent of moving time
Coasting rate, miles per hour per second 0.41

Motor. Detail improvements have been made in the motor—a longer commutator permits larger brush area and increased brush life. Greater protection over the front commutator V-ring minimizes the damage resulting in case of motor flashing. Better insulation on both armature and field coils has lengthened coil life and reduced chances of breakdown.

Many control details have been improved as a result of the accumulated experience with the earlier cars. Silver-faced wiping-type control fingers and interlocks, improved-type limit relay contacts, and similar developments have increased reliability further.

Improvements in wiring and layout worked out in co-operation with a wiring committee and the engineers of the car builders have resulted in better equipment arrangement and installation and reduction in the number of pieces to be housed, mounted, and wired.

A new design of truck has been completed so there are now two sources of supply.

CAR PERFORMANCE

With the various modifications, car weights have tended to increase. At the present time standard single-end single-unit cars weigh about 36,000 pounds empty. Also, the equivalent weight addition for rotational or flywheel effect has been increased by the addition of the drum brake on the drive shaft and by some increase in the weight of the resilient wheels. Car performance based on these weights and on the corresponding rates of acceleration and braking are shown, Figures 4, 5, and 6.

Schedule speeds and propulsion power consumption for varying stops per mile from 4 to 12 are shown in Figure 6. These are based on an acceleration rate of 3.5 miles per hour per second, dynamic braking at 3.15 miles per hour per second, coasting for 25 per cent of moving time, and 7-second stops.

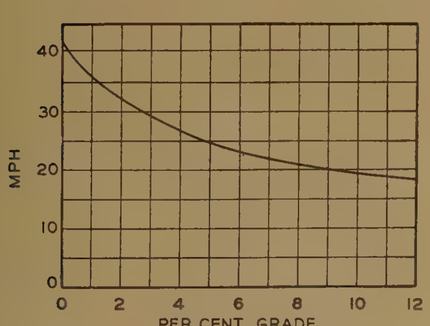


Figure 5. Balancing speeds on grades

Same car as described in Figure 4

Experimental Rural Radiotelephony

J. HAROLD MOORE
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RADIOTELEPHONE experiments providing telephone service to eight ranches were conducted near Cheyenne Wells, Colo., in 1946. Four ranches were reached directly by radio, and the remaining four were served by wire line extensions from the radio-equipped location most remote from the central office. The complete installation comprises an 8-station party line that functions in much the same manner as a conventional party line. Figure 1 shows the geographic arrangement of the facilities. This locality was selected for the experiment because it is sparsely settled and does not now have telephone or power distribution lines in the outlying areas; furthermore, a number of ranchers in this area had indicated a desire to obtain telephone service. The ranches involved in the trial are located from 11 to 21 miles southeast of the town, and the propagation paths between antennas at the central office and the various ranches are somewhat poorer than line of sight.

The first rural party-line telephone service utilizing radio installations operating on the subscribers' premises was undertaken experimentally in the vicinity of Cheyenne Wells, near the eastern border of Colorado. Radio links have been used to supply regular telephone service to eight ranches since August 20, 1946. The development of a standard rural radiotelephone system will be aided materially by the experience gained from these experiments.

The experiment was undertaken using frequencies in the 44–50-megacycle band in order that readily available equipment designed for mobile systems could be modified to accomplish the desired result. The 44–50-megacycle band is one of a number of locations in the spectrum where provision is made for rural telephone service under the Federal Communications Commission's frequency allocation plan.

OPERATION OF THE SYSTEM

The system is designed to operate like a common-battery signaling rural line with a standard appearance in a manual telephone switchboard. Subscriber stations are called by the telephone operator of this board, using 20-cycle code ringing. Each station telephone set is provided with a call key which forms part of the switchhook assembly of an otherwise standard combined telephone set. The contacts of the call key are arranged to provide for listening only, when it is not operated, and to provide for simultaneous talking and listening when operated. It may be operated by the subscriber when the handset is off its cradle and is restored automatically to the receive-only position when the instrument is re-

Essentially full text of paper 47-83, "Rural Radiotelephone Experiment at Cheyenne Wells., Colo," presented at the AIEE winter meeting, New York, N. Y., January 27–31, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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placed. Its purpose is to turn on the system, and its use reduces the likelihood of accidental operation of the system and interference with calls in progress and facilitates making reverting calls by permitting monitoring while the called station is being rung.

Figure 2 shows a diagram of the electrical arrangement. Each subscriber station is connected over a pair of wires through a cutoff relay to a hybrid coil, with branches leading to the radio transmitter and receiver. Associated with the hybrid coil and cutoff relay are devices for converting d-c signals to transmitter carrier, for translating received carrier to direct current, and for resupplying 20-cycle ringing current. Several subscribers may be served from one radio-equipped terminal, the connection being extended by a wire line as illustrated. The central office installation includes a radio transmitter and two radio receivers connected to branches of a hybrid coil, which is associated with a pair of wires leading to a jack in the switchboard and relays for converting and translating direct current, and for converting 20-cycle current to carrier pulses. Normally, all the receivers are energized ready to receive a call and the transmitters are turned off.

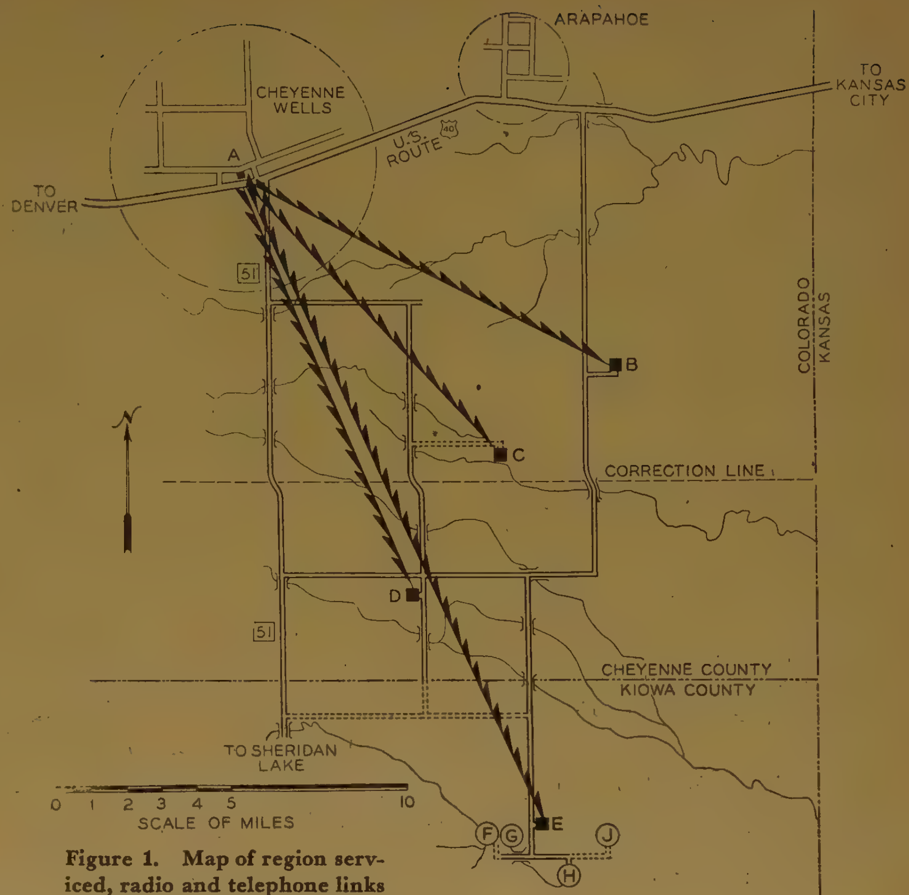


Figure 1. Map of region serviced, radio and telephone links

To make a call, a subscriber lifts his handset from its cradle and, if the circuit is not busy, operates the call key. This closes the wire line through the telephone and operates a relay which causes the radio transmitter to emit carrier at the regular frequency. This carrier operates a relay at the central office which starts the transmitter and closes the switchboard loop, causing the line lamp in the switchboard to glow. (This is the condition illustrated in Figure 2.) The operator plugs in the switchboard cord and completes the call through the switchboard in normal fashion. When the call is ended, the subscriber replaces the handset on the cradle, which automatically restores the call key, opening the wire line and thus releasing the relays and turning off both the subscriber's and the central office transmitters.

On a call for a station from the switchboard, the operator connects the calling cord to the line jack and rings the desired code. This operates a polar relay intermittently, causing the emission of pulses of carrier frequency at a rate determined by the frequency of the ringing current. This causes operation of relays in the subscriber's radio equipment, and the bells ring at all the subscribers' stations. In the interval between rings, all relays are restored to normal, and the central office carrier is turned off. Upon hearing his code, a subscriber answers by lifting his handset and then his call key, which turns on his transmitter. Reception of his carrier at the regular central office receiver causes the central office transmitter to emit steady carrier as in a call originating at his station.

On a reverting call (a call between subscribers on the same system) a subscriber restores his call key to the receive-only position after placing the call and operates it again after the called party answers. As the call key is normal when the central office carrier is received, the transmitter of the calling party automatically is made to operate on the alternate subscriber's frequency, reception of which at the central office operates a relay which changes the impedance of the balancing network at the hybrid coil, so that each subscriber hears the other by retransmission at the central office frequency and at the proper strength.

In the Cheyenne Wells system the central office frequency is 44.2 megacycles supplied by a crystal-controlled transmitter with maximum rated output of 60 watts. The carrier is keyed by 20-cycle input for signaling, and frequency modulated with maximum deviation of plus or minus 15 kc by speech. Both the transmitter and receivers, which also are crystal-controlled, are

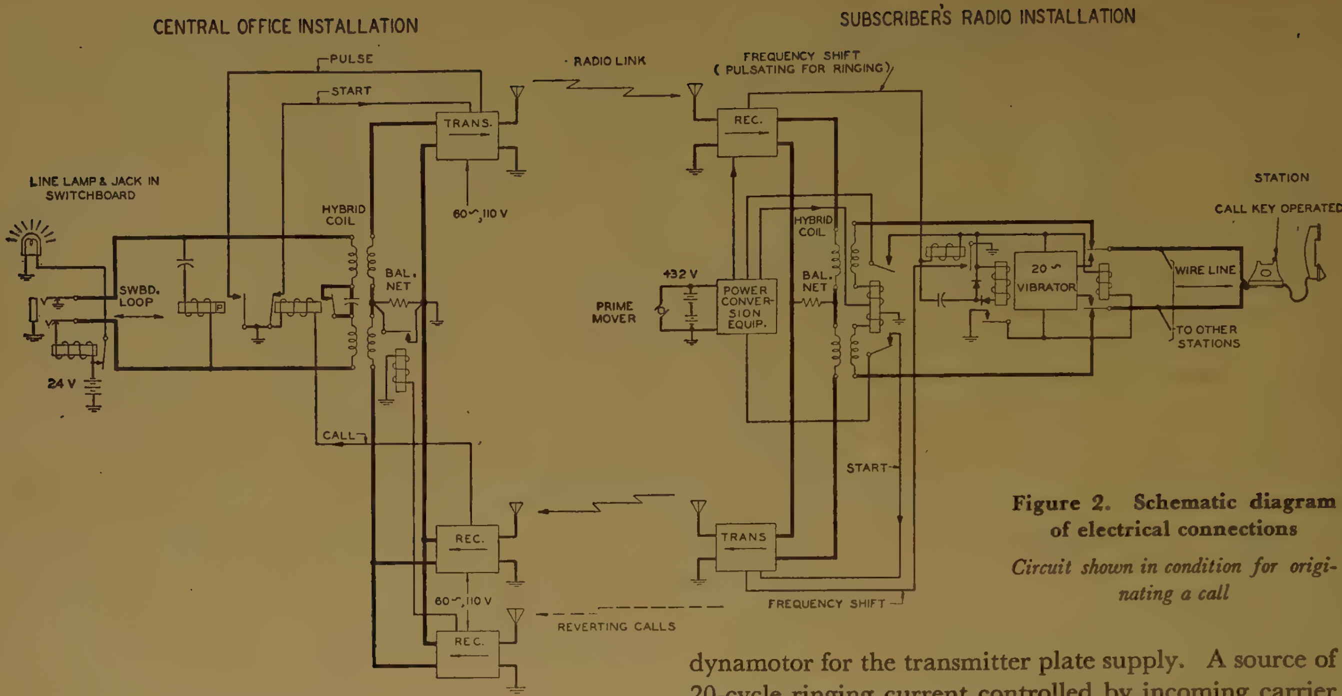


Figure 2. Schematic diagram of electrical connections

Circuit shown in condition for originating a call

powered from commercial 60-cycle, 110-volt supply. The antennas are vertically polarized half-wave type, fed by 72-ohm flexible polyethylene-insulated coaxial cable of 0.405-inch diameter. The transmitting antenna is clamped to the top of a guyed 90-foot wooden pole. The two receiving antennas (one for each of the subscriber frequencies) are mounted on crossarms atop a similar pole 50 feet away from the transmitting pole.

At the subscriber stations, the regular and alternative frequencies are 49.0 and 49.2 megacycles respectively, and are supplied from crystal-controlled transmitters having maximum rated outputs of ten watts. Transmitters are frequency modulated by speech with maximum deviation of plus or minus 15 kc; signaling is by unmodulated carrier. Receivers are also crystal-controlled. Antennas of the type used at the central office and some experimental *J*-type antennas are mounted on poles which range from 25 to 60 feet in height, depending on the distance from the central office. As shown by the illustration at the head of this article, the transmitting and receiving antennas are supported by the same pole at opposite ends of a pair of crossarms. Lightning protection is provided by an air gap at the feed point of the coaxial antenna and copper wires leading from the antennas to ground rods at the bases of the poles. These wires are bonded to the cable sheath.

Power for operating the subscribers' radio and station equipment is supplied from customer-owned power plants having 32-volt batteries which are charged by wind-driven and supplementary gasoline-engine-driven generators. Utilization of 32 volts to supply the vacuum tubes in the radio sets is accomplished by a combination of 100-cycle synchronous vibrators together with transformers and filters, by metallic disk rectifiers supplied with 100 cycles by the vibrators, and by a 32–400-volt dynamotor for the transmitter plate supply. A source of 20-cycle ringing current controlled by incoming carrier pulses is supplied by a 20-cycle synchronous vibrator circuit. The modified mobile radio and telephone signaling equipment is assembled on the customers' premises in a cabinet also containing power conversion equipment.

RESULTS OF OPERATION

During the period of preliminary tests of this system, June and July 1946, principal difficulties were:

1. Sporadic interference from frequency modulation broadcast stations. Initially, intermittent interference from frequency modulation broadcast stations in the order of 1,000 miles from Cheyenne Wells was observed at the subscriber locations, where at times the interfering carrier exceeded the desired signal from the central office transmitter by as much as 10 decibels and, therefore "captured" the subscribers' receivers. From a survey, frequencies lying between the frequency modulation broadcast frequency assignments were selected, 44.2, 49.0, and 49.2 megacycles, and operation at these frequencies has been found free of interference.

2. Bell taps from local thunderstorms. False operation of the subscribers' bells occurred at first during local thunderstorms. Replacement of the initial signaling arrangement with one which is selective to 20-cycle pulses and is not operated by single bursts, proved quite effective. Since the system was placed in regular service in August 1946, the only troubles encountered have been of a minor nature, involving tube and vibrator replacements.

The participating ranchers, whose continuing interest and co-operation have facilitated greatly the progress of this experiment, have expressed general satisfaction with the service provided by this system. While it is too early to draw any general conclusions from the rural radio experiment described here, the results of utilizing, for the first time in history, radio installations on the subscribers' premises for furnishing regular telephone service are encouraging. It is expected that the experience gained will aid in developing a standard rural radio-telephone system especially designed to meet the requirements of this type of service.

Marking of Electric Equipment

TED POWELL

Standardization of electric equipment marking is of vital interest to technicians who must install and operate the apparatus. Although many standards have been formulated, more are needed and those that do exist require greater utilization. During World War II it was brought out that existing standards do not encompass the field of name plate marking, and at that time there was a vital need for such a practice.

ONE of the perplexing problems with which electrical technicians were faced during the grueling war years was the frequent use of arbitrary methods in coding and identifying equipment components, wiring, and blueprints in the electrical field. The problem still exists.

One of the simpler types of marking ambiguities, which was accentuated during the war, is the method of indicating mechanical rotation. The general terms right-hand, left-hand, clockwise, or counterclockwise sometimes are employed with no additional information. The terms left-hand and right-hand are not generally as effective as the terms clockwise and counterclockwise for rotation designations because they tend to become confusing in the case of units located overhead or mounted diagonally. The position from which rotation is viewed in relation to the machine must be considered in marking. Indicating arrows help to eliminate ambiguity in most cases.

A-C MOTOR AND GENERATOR MARKINGS

A similar problem is encountered in polyphase motor and generator markings. A 3-phase motor's or generator's leads usually have so-called phase markings on the three or more connections. Theoretically, when these marked leads are connected to a correspondingly marked power supply, the motor should rotate in the proper direction, and the generator should produce a properly phase-rotated output. In actual practice, however, the technician cannot rely on the aforementioned to be true because the markings of individual manufacturers are different and because they fail to indicate the actual phase rotation of the windings.

Technicians generally must employ time-consuming trial-and-error checks with energized equipment in order to determine the actual phase-rotation. Standard notation of phase rotation and corresponding marking of motor and generator leads with associated mechanical rotation information supplied as previously mentioned would be of great help in installation work, and units manufactured by several companies could be installed in the same system with the assurance that they would all rotate or produce a phase-rotated output in the proper direction with the system energized.

SELSYN DIAL AND WIRING MARKINGS

The wide military and industrial application of self-synchronous systems to remote indication and control purposes, and the generally slight familiarity of the average engineer and technician with this device, has resulted in some confusion. Six different factors may be present to cause reversed rotor or dial rotation, reversed dial readings, or reversed control signals, even though all installation wiring apparently has been installed properly according to the blueprints. They might be listed as follows:

1. Reversed readings caused by dial calibrations engraved in both clockwise and counterclockwise directions.

2. Reversed dial rotations caused by gear trains between the rotors and their indicating dials in multiple-dial indicating instruments.

3. Reversed dial readings caused by fixed-dial-and-rotating-pointer indicators in a fixed-pointer-and-rotating-dial indicator system.

4. Reversed dial calibrations or dial rotations in multiple concentric dial indicators caused by reversed calibration of fixed or rotating dials, or by reversed rotation of dials in triple-concentric dial-type "match-the-pointer" or "relative-and-true" bearing indicators. In such instruments, a concentric ring-dial or "bug" dial reads simultaneously against an inner rotating calibrated dial and an outer fixed calibrated dial.

5. Reversed dial rotation caused by the clockwise "phase" rotation (signal rotation) of some signal windings and the counterclockwise rotation of other windings.

6. Reversed dial rotation caused by the connection of both rotating-field-and-stator-Y-winding and stator-field-and-rotating Y-winding indicators in the same system.

Standardization of dial rotation and calibration would permit different manufacturer's units to be interchanged much in the manner which is possible with most motors, generators, or power transformers.

COMPONENT NAME PLATE MARKINGS

The lack of detailed information on circuit name plates was another problem which confronted wartime technicians. This was especially true of electronic servomechanism drives in installation, test, and maintenance.

Ted Powell of Maspeth, N. Y., was electrical test supervisor of the ship repair force, New York Naval Shipyard, Brooklyn, N. Y.

Whenever operational troubles developed, the lack of full information was often a handicap, especially when detailed data was lacking on the blueprints as well as on the equipment and component name plates. Swift and efficient meter and test equipment checks were made more difficult as a consequence.

Some of the necessary values usually absent were the ohmic resistance of windings; relative phasing and polarity markings for transformer and saturable-core reactor windings; wattage and accuracy values of resistors; working voltage and accuracy values of capacitors; and coil current and voltage values and the air-gap contact-point settings for relays. Marking standards might be set up which would require the indication of all pertinent values for circuit components.

EQUIPMENT WIRING MARKINGS

Arbitrary and unrelated wiring codes are employed too often for the wiring of most electric equipment. This presents a problem when prints and conversion charts must be referred to continually. Obvious coding systems, which indicate circuits and equipment involved without the need for code charts, are used with considerable success by the military services. A simple type of related coding system is one in which the first letters of major equipment items are prefixed or suffixed to all their allied electric apparatus and wiring in a particular setup.

Where elaborate installations are involved, an organized and systematic number and letter coding system is advisable for the cables, wiring conductors, and terminal connections at the connection boxes, connector plugs, and control switches. Such practice is typical of military installations because of the need for rapid identification when repair is required following battle damage. In commercial work this is not practical now because of the high initial cost. Consequently only partial marking or no marking at all is done, and subsequent repair and alteration is relatively difficult.

Where wiring coding is practical, the box, plug, and switch coding numbers might be integrated with the cable numbers. Minor differences in the numbers could indicate the components involved and they could be located easily.

TERMINAL BLOCK MARKINGS

Another nonstandardized identification procedure which results in many production difficulties is the marking of instrument wiring terminal-block barriers. The blocks, which may be mounted either vertically or horizontally, may have wire number markings above or below the terminal posts, to either side, to both sides on the same block, split with half the number above and half to the side, or split with half above and half below. Some sort of standard for all wiring terminal-post markings might save production and test man-hours and reduce probability of wiring errors.

WIRING AND COMPONENT COLOR CODING

Ordinarily, color coding is effective under certain conditions. However, when applied indiscriminately in involved equipment and wiring applications, it may become a curse instead of a blessing. Similiarly, the color coding of conductors, capacitors, and resistors used in electronic devices results in maintenance and repair problems.

Careful study of statistics concerning the optical characteristics of the human eye reveals some rather interesting facts. The human eye behaves differently under various lighting conditions, particularly with respect to color sensitivity and evaluation characteristics. To complicate matters further, the percentage of people with subpar vision in the large industrial areas is surprisingly high. The average man does not possess good color sense. In some groups tested, four out of five men actually had some form of color blindness which ranged from slight weakness in one color to total color blindness.

Women, however, generally appeared to possess unusually good color vision and in some groups tested the reverse ratio was indicated—only one woman in five was found to have appreciable color blindness of any type.

The production man does not always work under favorable conditions. It is difficult to concentrate on and evaluate 40 to 60 multicolored cable conductors in the field. This is especially true when workers have walked over them, or handled them with dirty or perspiring hands. Swirling welding fumes, dusty air, dim and yellowish lights, excessive heat and humidity, and crowded working areas aggravate the conditions still further.

Wartime experiences showed that not much trouble with color codes was experienced on the assembly lines where most of the workers were women working under favorable conditions, and considerable trouble was encountered in the field where men did installation and test work under adverse conditions.

In the matter of color coding of circuit components such as resistor and capacitor units, somewhat similar problems present themselves. After a component has been handled, knocked about, struck by tools, scorched by hot soldering irons, and operated at normal or above normal temperatures, whatever color code dots and stripes it may originally have had, fade or disappear and leave a miniature mystery. A numerical value rating method, using stamped numbers and letters in the body of the component or attached metal, fiber, or plastic tags might aid identification.

Cable color coding generally has worked out fairly well in smaller cables with about two dozen or less conductors, but it has presented something of a problem in the larger multiconductor cables where three colors per conductor are involved. The adoption of number

and letter codes, or a combination of number and color code systems to decrease the number of colors involved appear to be possible solutions to this circuit and component identification problem.

BLUEPRINT MARKINGS

Because the design and drafting sections of industries suffered particularly during World War II from the universal skilled-manpower shortage, management of necessity allowed them to slide by with inadequate blueprints. The importance of detailed blueprints which are understood readily cannot be overemphasized in modern industry.

The lack of application of standardization of blueprint symbols has been pointed out by many engineers and technicians in recent years. For example, in a modern military ordnance installation, blueprints using four different types of symbol systems are found. Blueprints for the hydraulic servomechanism power drives use standard power symbols for the motors, controllers, and limit-switch circuits. The fire-control radar blueprints use standard radio symbols. The servomechanism drive blueprints for the light antiaircraft machine-gun cannon mounts use a combination of power and radio symbols. The sound-powered telephone, firing, cease-firing, shell-loading signal lights, and the lighting circuit blueprints use military symbols. Standard drafting room practice as set up by the American Standards Association is not followed very closely. The fact that many organizations are not familiar with established standards cannot be overlooked.

To a certain extent, the lack of standardization of blueprint type nomenclature also presents a minor problem. The designations for some of the many types of prints used in the electrical and electronic fields (isometric, deck, level-or-floor, general arrangement, elementary, schematic, elementary-schematic, detail, assembly, exploded-view, quarter-section cut-away, and action-flow or functional schematic) apparently differ among industries and some sort of standardization of blueprint type terminology might prove beneficial.

Another blueprint problem is the lack of sufficient information markings. In elementary (or schematic) blueprints, phasing, voltage ratios, and ohmic resistance values of inductive units; accuracy and wattage ratings of resistors; voltage and accuracy ratings of capacitors; coil resistance, coil current, and contact-point air-gap settings of relays; "multiplication-table" type charts of cold-circuit ohmmeter readings and hot-circuit voltage and current readings at terminal blocks and tube sockets; and so forth, are omitted. In general arrangement, isometric, and deck blueprints, necessary mechanical information concerning installations is often lacking.

A factor which tends to cause some trouble in handling and identifying blueprints, is the practice of using arbitrary and unrelated number and letter codes for the prints. It is usually quite practical to apply serial codes which indicate the type of equipment involved and the date when introduced. The military services use with considerable success codes permitting systematic and efficient filing and rapid identification out in the field.

Printing Electronic Circuits

A new method of printing wiring and circuit components on an insulated surface, developed by the National Bureau of Standards in co-operation with electronic manufacturers for the tiny generator-powered radio proximity fuse, is applicable in the design of devices where extreme ruggedness and small size are imperative. The principal effect of the printing methods, which include hand spraying and photography, is to reduce electronic circuit wiring to two dimensions. Illustrated is a size comparison between a conventional 2-stage amplifier and a miniature amplifier for use with subminiature tubes. Their characteristics are identical.

Recent Advances in 3,600-RPM Turbine Generators

In the brief period of ten years the 3,600-rpm turbine generator has so grown in ratings that it has driven, in effect, the slower speed 4-pole generating unit from the central-station field except for the largest capacity installations. But here, too, the death knell is being sounded by the construction of a 100,000-kw 3,600-rpm unit that will operate with steam at 1,500 pounds per square inch gauge pressure and 1,050 degrees Fahrenheit, the highest inlet temperature yet attempted.

THE increase in ratings of 3,600-rpm generators can be traced through a series of developments that have resulted in a reduction of losses, increase in heat dissipation, increase in allowable stresses, and methods whereby a more efficient use of available materials may be obtained. Increase in turbine ratings also has depended on improved materials for higher temperatures and larger exhaust blades.

With the early 1930's, condensing turbines generally were limited to throttle conditions of 400 pounds per square inch gauge pressure and 750 degrees Fahrenheit. Although thermal studies indicated that the use of increased pressures and temperatures would result in operating economies, the cast-carbon-steel materials for the casing limited the upper temperature to approximately 750 degrees Fahrenheit, and it was possible to raise only the pressure. High pressure and low temperature caused excessive moisture at the exhaust end, and consequent erosion of the blading. Because of this, the exhaust steam quality was limited to 12 per cent moisture, thereby limiting the pressure as well as the temperature. This was overcome in some plants by the provision of interstage reheating, a principle which proved highly successful and economical. But even interstage reheating was limited by the ability of the exhaust blading to pass efficiently an increase in steam flow. With a given speed and permissible energy content of the steam at the condenser this requires a larger last row annulus area, that is, longer blades. The limit to exhaust blade length is set by the ability to design a blade of such proportions and material that it, as well as the rotor, can withstand the high peripheral forces involved.

In 1929, a 17-inch blade was designed for 3,600-rpm machines. The resulting increase in tip speed over that of the previous 12-inch blade caused a 60 per cent increase in centrifugal force.

Increased capacity could also be obtained by using tandem compound units. In 1929 10,000 kw was the maximum that could be gotten from a single-case machine with 17-inch exhaust blading. But Virginia Public Service Company wanted more capacity for its Bremo Bluff station and purchased a 15,000-kw tandem-compound machine. Because the exhaust steam was split into two paths it was possible to obtain 20,000 kw though this capacity was not required at the time.

The generator then became the limiting factor. By 1936 generator capacity had been boosted by improved rotor end-turn ventilation, by a better method of dynamic balancing, and by improvements in forgings for the generator shaft. Over a period of 20 years changes in the rotor forging permitted a 70 per cent increase in allowable working stresses without reduction in the factor of safety. In addition, improvements in design, materials, and inspection increased the maximum rotor diameter approximately 50 per cent, and increased the length of the body with respect to the diameter.

Most important of all generator improvements during this period, however, was the application of hydrogen cooling. It has made possible an increase in rating of any given-size generator. Not only does hydrogen have a high coefficient of heat transfer, but it also has a low coefficient of friction. Both of these factors contribute

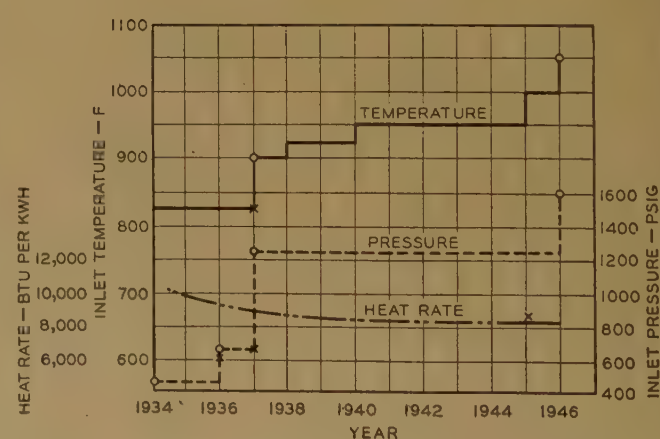


Figure 1. Trends in condensing turbine steam conditions and heat rate

This article was prepared from information supplied by **C. C. Franck, F. K. Fischer, John Carlson,** and **J. W. Batchelor** (A '38) of the steam-turbine and generator engineering departments, Westinghouse Electric Corporation, East Pittsburgh, Pa.

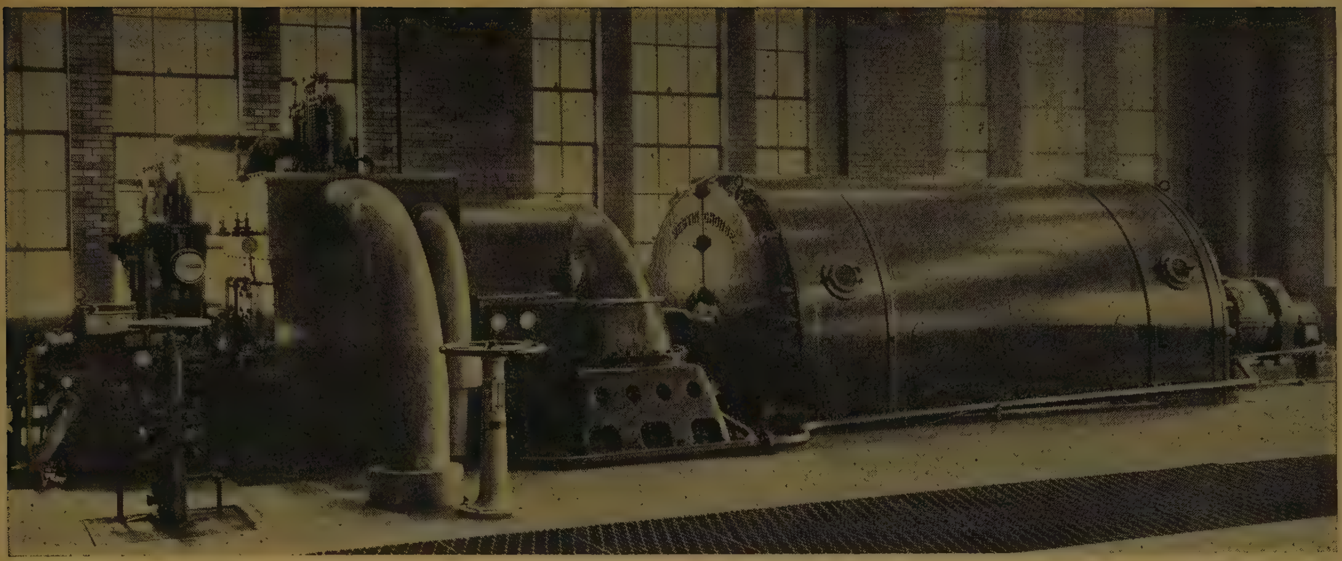


Figure 2. The era of high-speed turbine generators began about 16 years ago with the 10,000-kw units; this early model was purchased in 1929 by the Peoples Gas and Electric Company of Mason City, Iowa

to provide greater efficiency as well as better cooling.

Advances also were made in turbine engineering. Exhaust end blade lengths were increased to 20 inches and blade tip speeds increased to 1,257 feet per second, slightly greater than sea level sonic velocities. Carbon-molybdenum steels became available for turbine casings. In addition, the use of stellite shields on the blade inlet edges and the use of water catchers tended to minimize erosion.

The trend toward increased pressures and temperatures made the smaller physical size of the 3,600-rpm machine even more advantageous. In 1938, the capacity of the single-case machine was increased to 25,000 kw. Later the ASME–AIEE standardization program and design improvements resulted in the use of a similar single-case machine for a nominal rating of 30,000 kw and a maximum turbine capability of 33,000 kw.

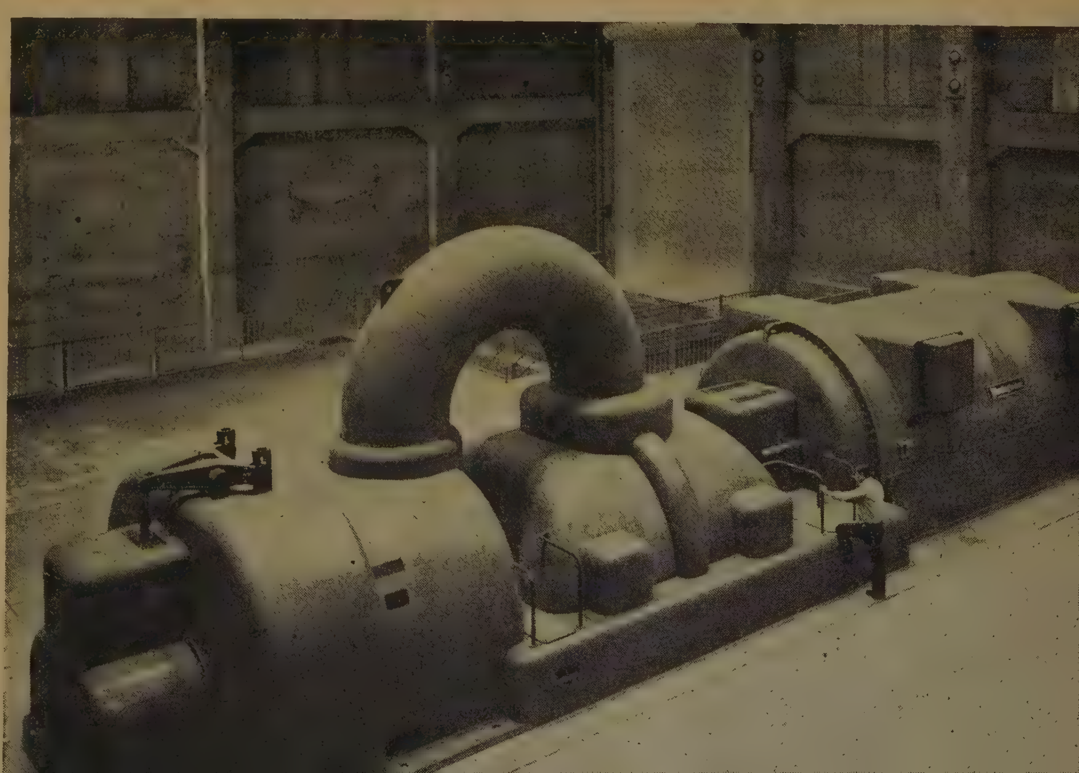
CROSS-COMPOUND UNIT

In 1942, a cross-compound unit comprising two double-flow low-pressure elements in tandem was used for a nominal rating of 100,000 kw and maximum output of 125,000 kw. A further increase of exit blade length to 23 inches will bring the single shaft tandem type machine to a capacity of 100,000 kw at the Sewaren station of the Public Service Electric and Gas Company of New Jersey. The root structure of these blades must resist a force of greater than 80,000 pounds tending to lift each blade out of the spindle, or the disk must resist a total pull of 5,000 tons.

OPERATION AT HIGH TEMPERATURES

At operating temperatures above 950 degrees, the physical strength of material diminishes rapidly making a full knowledge of the actual working stress necessary. Uncontrolled thermal stress when added to the steady-state stress easily might exceed the allowed design mar-

Figure 3. This modern 65,000-kw tandem-compound machine is operated by the Los Angeles Bureau of Power and Light



gin. Therefore, the high-pressure section of a turbine designed for operation above 950 degrees must be a very simple structure. The steam chest is separated from the turbine casing thereby making the turbine casing a simple shell.

The nozzle chambers, which normally are cast as part of the turbine casing, are separate and flexibly fixed to the basic structure of the cylinder. This construction eliminates a differential temperature gradient through the adjacent nozzle chamber walls, and in a measure eliminates this component of the thermal stresses. The steam chest is fabricated from individual forgings that insures a soundness of such parts and preferably is located at the same elevation as the turbine casing in order to eliminate vertical components of expansion in connecting pipe. For temperatures above 950 and including 1,000 degrees, it is planned to use a low-chrome-molybdenum steel. For temperatures above 1,000 degrees stabilized 18–8 stainless steel will be used.

Major Improvements in 3,600-RPM Turbine Generators (1930 to 1946)

Improvement	Result
1. Multiple path ventilation	Better cooling, increased capacity per given size generator
2. Rotor winding ventilation	Decreased operating temperature, thus increasing generator capacity
3. Radial slot rotor design	Higher flux densities and increased capacities of generator
4. Better silicon steels	Higher flux densities and increased capacities of generator
5. Stellite shields for blades	Less exit blade erosion. Higher pressure
6. Rotor and turn ventilation	Increased generator capacity because of decreased temperature
7. Hydrogen cooling	Higher heat transfer and reduction in windage loss, hence better efficiency and reduction in temperature rise. Greatly increased generator capacity
8. Dynamic balancing	Decreased vibration, thus decreased stresses. Higher capacities
9. Better generator forgings	Improved mechanical and electrical design
10. Improved blade roots	Higher peripheral blade speeds. Longer exit blades
11. 20-inch exhaust blading for turbine	Increased steam flow resulting in higher turbine rating
12. Carbon-molybdenum steels	Better castings. Increased operating temperature
13. Nickel-chromium-molybdenum steels	Better forgings. Better turbine efficiency
14. More effective water catchers	Less exit blade erosion. Higher pressure
15. Special stator mounting	Isolated stator double frequency vibration
16. Hard drawn copper for rotor windings	Allowed increase in stresses and increased size
17. Undercut pole to remove material	Decreased rotor double frequency vibration
18. Method of calculating fault stresses	Increased generator capacity through better design
19. Mechanical torque analyzer	Better generator shaft design
20. 23-inch exit blade for turbine	Increased steam flow resulting in higher turbine rating
21. Separate steam chest from turbine casing	Decreased stresses. Higher temperature operation and indirectly, higher pressures
22. Improved high temperature steels	Higher temperature operation
23. 15-pound-per-square-inch hydrogen pressure	15 per cent increase in generator capacity over 1/2-pound hydrogen pressure

The main generator at Sewaren will be hydrogen-cooled with a gas pressure of 15 pounds per square inch. This increase in gas pressure raises the permissible generator rating 15 per cent beyond that corresponding to the conventional 1/2-pound per square inch gas pressure, and

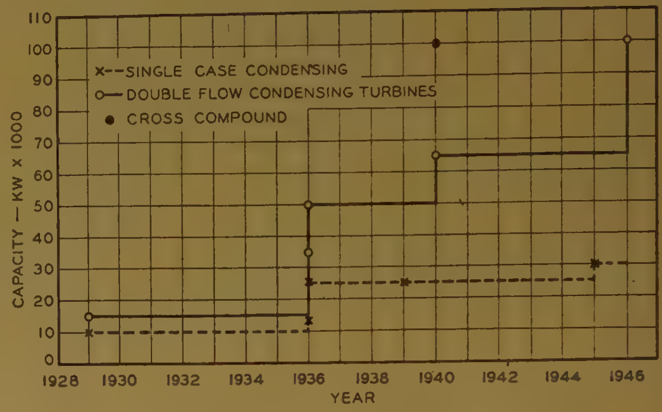


Figure 4. Progress of 3,600-rpm turbine generators

35 per cent above its rating in air. The generator has propeller blowers with blades of air-foil cross-section which require a relatively small amount of space on the shaft.

MULTIPLE-PATH VENTILATION

Multiple-path ventilation has replaced the previously used radial system because of the increased friction losses which accompany the increase in length. Rotor ventilation which formerly amounted to dissipation of loss from the rotor surface, now is obtained by a system of ducts located beneath the rotor winding. These ducts are connected to holes drilled down through the coil retaining teeth, so that the total cooling surface is increased. The end turns of the rotor winding are held in place by retaining rings drilled to allow passage of the ventilating medium over the end turns. The blocking of these end turns is constructed to direct the ventilating medium over the greatest surface at a velocity that allows the maximum dissipation of heat. Supporting the retaining ring and end plate from the rotor body, and thus keeping the end plate completely free from the shaft, reduces any restriction to the flow of the ventilating medium to either the rotor body or the end turns of the winding.

Should the need arise, a tandem-compound, 3,600-rpm turbine can be built today for more capacity by enclosing a triple or even a quadruple flow exhaust end under a single case. Refinements in design, improvements in materials, better cooling, and changes in characteristics ultimately may raise the present limit in generator rating to 150,000 kva or beyond. In that event, the 1,800-rpm machine likely will pass from the central-station picture.

Electronics and the Future

E. U. CONDON
MEMBER AIEE

The vast influx of reports on new and not easily understood developments in the various fields of electronics easily can be quite baffling to the electrical engineer. An understanding, such as is provided here, of recent expansion in electronics research is helpful to give the correct perspective with which to view the electrical industry.

ELECTRONICS has not been given, so far as I know, an officially agreed-upon definition. Generally speaking, electronics is a part of science, it is an art, and it is an industrial practice. *It is the science, art, and industry concerned with electrical phenomena involving electrically charged atomic particles, outside of solid and liquid bodies.* With this understanding we have a fairly clear separation of the field from the classical branches of electrical engineering and at the same time a definition that is broad enough not to restrict us to those particular phenomena in which only electrons are involved.

Electronics is thus a very broad subject. It embraces all phenomena connected with the passage of electric currents through gases and high vacua. Such phenomena are utilized for a wide variety of purposes: the generation of high frequency electric power, its amplification, the control and rectification of electric power at all frequencies, production of electric current from light sources, and production of light from electric currents (including X rays and gamma rays as special forms of light). Phenomena associated with the propagation of radio waves in the ionosphere of course also are included, as is the study of cosmic radiations from interstellar space, and special means for producing beams of atomic particles of high energy for the study of nuclear physics.

Electronics may be subdivided into 11 major topics. The first four of these are branches of our subject which are already well launched as a result of the work of the war years. These are

1. The general field of radar, loran, and air and sea radio navigation aids including associated microwave techniques.

2. The broad field of television, now ready for development as a popular service after long delays caused by the war.

3. The broad field of inductive and dielectric heating for which there seem to be limitless possibilities of special applications in the metallurgical and plastic industries.

4. The field of electronic instrumentation and control, including the general concept of the servomechanism.

These four main branches of our subject are all relatively new developments, but there already exist large industrial activities built on them, so that they are becoming mature and ready to join the main classical branches of electronics—namely, the art of radio communication and the art of rectification and control of large blocks of power by gaseous conduction devices such as the thyratron and the ignitron. Because these four branches are discussed in such great detail so often, I shall endeavor to point out seven additional facets to modern electronics.

ELECTRONIC COMPUTING DEVICES

Only those who are skilled in mathematical physics realize how very limited is man's ability to obtain analytical solutions to important problems in applied mathematics. Great as has been the progress of the past century, the time has come when many problems of great importance, especially in hydrodynamics, aerodynamics, and meteorology can be handled only by methods based on elaborate arithmetical computation. For many years now it has been the practice to introduce artificial and unjustified approximations into the setting up of many such problems in order to reduce them to a form tractable by our limited analytical attainments. As a result one often is confronted with this unsatisfactory situation: A theoretical calculation is made and the results are compared with experimental data and discrepancies are found. The question now is, are these discrepancies due to an improper physical formulation of the problem, or due to the inadequacy of the mathematical methods used in making specific calculations from a correct physical formulation? Such a situation is clearly intolerable.

However, calculations required for problems of current interest are so elaborate as to require many man-years of work by skilled computers. Aside from the cost involved, such a situation slows down progress because one has to wait too long to get an answer by old-fashioned hand-operated computing machines.

A good deal of progress was made during the war in opening up the field of application of electronic methods to rapid calculations. The first major step in this direction is not, strictly speaking, electronic but electromechanical. It is the sequence controlled calculator built by Professor Aiken at Harvard from standard

Essentially full text of an address presented at the National Electronics Conference, Chicago, Ill., October 3, 1946.

E. U. Condon is director, National Bureau of Standards, Washington, D. C.

International Business Machine units. In addition, several relay computers have been or are being built at the Bell Telephone Laboratories and the International Business Machine Corporation.

Until recently, this work at the Bell Telephone Laboratories has been under the technical direction of Doctor G. R. Stibitz and S. B. Williams. Such machines have been built for the Naval Research Laboratory in Washington, for the Aberdeen Proving Ground and other Army research centers, and for the Watson laboratory of Columbia University under the direction of Doctor W. P. Eckert.

The first major development in the electronic field was the *ENIAC* (electronic numerical integrator and computer) built under the direction of J. W. Mauchly and J. P. Eckert at the Moore School of Engineering, University of Pennsylvania, for the Army Ordnance Department. The next major step in the field was the development of the *EDVAC* (electronic discrete variable computer), now under construction at the Moore School in Philadelphia. Additional projects in this field include the joint project of Professor J. von Neumann of the Institute of Advanced Studies in Princeton and Doctor V. K. Zworykin of the Radio Corporation of America laboratories in Princeton. Also worthy of mention is the research program of the National Bureau of Standards in this field being organized under the joint direction of Doctor John H. Curtiss and Harry Diamond. This project includes an immediate program of production of machines for the Bureau of the Census and for use by the Navy in a proposed National Mathematical Computation Center together with a long range program of fundamental development of components for such machines.

The *ENIAC* is a rather remarkable electronic device involving a large assemblage of 40 panels, employing approximately 18,000 vacuum tubes and 1,500 relays. Numbers are transmitted through the machine as a sequence of pulses for the various digits, the individual pulses lasting 2 microseconds separated by approximately 10 microseconds. The basic arithmetic operations are carried out in terms of synchronized performance of various calculating units, each elementary operation being assigned a time of 200 microseconds. This basic time unit is to be made shorter in the newer machines under development. Some idea of the speed of operation of the machine is given by remarking that it can multiply one 10-digit number by another 10-digit number in about three milliseconds.

Evidently such a machine is only useful if it is made to carry out a whole sequence of arithmetical operations without intervention of human beings with their enormously slow reaction times of the order of 200,000 microseconds.

Probably the part of this field which today provides the greatest challenge to inventive ingenuity is the development of memory units. In a long and involved calculation one needs to be able to store in the machine some numbers which are produced in intermediate stages of the calculation and then be able to produce them as input to the machine at later stages of the calculation. Space does not permit a more exact formulation of the need.

MASS SPECTROMETERS FOR CHEMICAL ANALYSIS AND CONTROL

By a mass spectrometer is meant any high vacuum device in which chemical substances in the vapor phase are ionized by electron bombardment and the products of ionization subsequently are passed through electric and magnetic fields in such a way as to separate out the ions by mass. The mass spectrometer emerged from the pure physics laboratory some 30 years ago after initial development by J. J. Thomson and F. G. Aston in England. Especially valuable contributions to the development were made in Chicago by Professor A. J. Dempster of the University of Chicago. Later important developments were made at Princeton by Professor H. D. Smyth and Professor W. Bleakney, and at the University of Minnesota by Professor J. T. Tate and his students, especially Professor A. O. Nier.

Of what use is the mass spectrometer? In fundamental physics it makes possible the determination of the existence of different atomic isotopes and their relative abundance, and thereby becomes the detection device that is essential to all use of stable atomic isotopes for chemical researches by the tracer technique. Special forms of the mass spectrograph have been developed, particularly by Professor K. T. Bainbridge of Harvard, for the precise measurement of atomic masses, thereby

Figure 1. Gas-filled tubes that control the d-c power supplies of the ENIAC (electronic numerical integrator and computer)

giving important data on the energy of binding of atomic nucleuses. Other special forms adapted to production of high ion current were developed under Professor E. O. Lawrence at the University of California for use in separation of the uranium isotopes. This development matured into the construction of one of the multi-million-dollar isotope separation plants at Oak Ridge, Tenn. This is a special use which probably is already obsolete since other methods of isotope separation have already proved to be superior.

The form of mass spectrometer which, it seems to me, is most likely to be of continuing research and industrial significance is that adapted to chemical analysis of complex gaseous mixtures. Such instruments have been developed by Professor Nier of Minnesota, by Doctor J. A. Hipple of the Westinghouse Electric Corporation, and by Doctor H. W. Washburn of the Consolidated Engineering Corporation in Pasadena, Calif. They are already finding important application in the hydrocarbon industries—that is, in the manufacture of automotive fuels and of synthetic rubber. Although they have not as yet been adapted directly to plant process control, so far as I know, I predict that this will become one of the important developments of the future. Great advances in this field have been made by the study of infrared absorption spectra and through the use of the mass spectrometer. Important contributions to the development of standard methods of analysis are being made at the National Bureau of Standards through a co-operative venture with the American Petroleum Institute, directed by Doctor F. D. Rossini, involving the development of infrared methods by Doctor C. J. Humphreys and applications of the mass spectrometer by the group headed by Doctor F. L. Mohler.

I am sure that in this direction lies a great opportunity for further co-operation between electronics men and chemists, leading to further development of instruments suitable for commercial service and their special adaptation to particular problems of research and plant control.

PHYSICS OF RADIO PROPAGATION

It is important to remember that were it not for the ionized regions of the upper atmosphere, radio communication would be a purely local, almost line-of-sight affair. The ability of communication systems to extend over great distances is now known to be due to the reflecting properties of the ionized regions which we call the ionosphere. If the ionosphere were a simple mirror located at some definite height and reflecting strongly radio waves of all frequencies, the situation would be quite simple. However, the degree of ionization in the upper atmosphere is shifting continually with changing conditions of radiation from the sun in ways that are far from fully understood. The exact behavior of the ionized regions depends on the earth's magnetic field as well as the degree of ionization over the path of communication. The causative factors which determine the earth's magnetic field are themselves by no means well understood in spite of many years of diligent study.

Yet it is hardly possible to overestimate the importance of complete and accurate understanding of the phenomena of the ionosphere. Not only is ordinary radio communication service over long distances completely dependent on such knowledge, but also the proper operation of aids to long distance aerial and sea navigation, and eventually the means for guiding long-range missiles which some people think we some day may have to direct against our fellow men while they do the same to us in some future war.

The whole study of radio propagation includes also a proper analysis of the factors affecting radio wave propagation in the lower atmosphere or troposphere. This region, where ionization effects are negligible, apparently does not affect the propagation of radio waves of broadcast frequency or the usual short waves. But meteorological conditions do affect the propagation of ultrashort waves and especially microwaves. This cuts both ways, at the same time giving the weather men a new tool for study of weather conditions, and making it necessary for the radio man to consider the way in which meteorological factors affect his operations.

In this field great advances were made during the war. Stations for observation of the ionosphere were operated in the Pacific theater by the Army and Navy and also the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, D. C., which had pioneered in ionospheric studies since the basic research of Breit and Tuve in 1924 when radio pulses first were reflected from the ionosphere and the results interpreted as giving a measure of the height of the reflecting layers as in modern radar. Similar programs also were conducted by the British throughout the British Empire and by the Russians. Of course, the Germans and Japanese also had extensive programs of ionospheric observation, but their results were not available to us until after the war.

All available data were channeled into the National Bureau of Standards where it was handled by the staff of what was known as the interservice radio propagation laboratory, operated co-operatively under the auspices of the Joint Communication Board of the Joint Chiefs of Staff. After the close of the war, arrangements were made for the continuance of this work on a peacetime basis. This plan has called for organization of the central radio propagation laboratory as a division of the National Bureau of Standards, under policy guidance of an executive council representing government and private industry interests in radio propagation.

The central radio propagation laboratory now has a staff of approximately 200 and has taken over the operation, or has contracted for the operation, of a chain of ionospheric observing stations located at Fairbanks and Adak in Alaska, at Guam, at Manila, at Leyte, at

Palmyra, in Hawaii, at Louisiana, at Trinidad in the West Indies, and at Stanford University in California, in addition to its home station at Sterling, Va. This laboratory has a broad program of fundamental research which includes co-operative arrangements with the Harvard College Observatory at Climax, Colo., the United States Naval Observatory in Washington, D. C., the Mount Wilson Observatory near Pasadena, Calif., and the McMath-Hulbert Observatory in Michigan.

In addition this unit of the National Bureau of Standards maintains close liaison with similar groups working in Britain and in Russia. Co-operative work with the British and the Russians in this field is thoroughly satisfactory. The output of all this work, in addition to fundamental research in the physics of radio propagation, also leads to the preparation of predictions of conditions affecting radio propagation, which are available to the public in the form of a special series of publications from the National Bureau of Standards. This is a continuation of a prediction service that was available, on a restricted basis, to the Armed Forces during the war, but which is now generally available for use. Predictions of ionospheric conditions are made three months in advance in a monthly publication. In addition, special warnings of disturbed conditions are sent out over the National Bureau of Standards broadcasting station, *WWV*, and are provided to newspapers through special reports distributed by Science Service.

This very vital work is clearly of the utmost importance to the future development of electronics, and by its nature is dependent for success on whole-hearted international co-operation. So far there is every indication that the service established by the United States Government will co-operate effectively with other national services to the end that all of us may quickly gain a better understanding of all the factors affecting radio propagation.

DEVICES FOR ACCELERATING ATOMIC IONS

Nearly all that we know about the structure of the atomic nucleus was learned from experiments conducted by bombarding various targets with streams of high energy protons, deuterons, electrons, or helium ions, obtained by multiple acceleration as in the cyclotron, by means of the electrostatic generator of Van de Graaff, or by various circuits for rectification and multiplication of voltage provided from the 60-cycle supply.

Prior to the war there were a number of transformer-rectifier sets which operated up to a million or a million and a half volts. These could provide steady voltage and currents of tens of milliamperes and have been developed into machines for production of X rays of great penetrating power used during the war for industrial radiography and also finding increasing application in hospitals for cancer therapy. Before and during the war there were further developments of the Van de Graaff type of generator carried out by Professor John Trump of Massachusetts Institute of Technology and also by Professor R. G. Herb of the University of Wisconsin, which resulted in machines capable of giving up to four million volts, producing an ion beam of great homogeneity in energy of the several particles.

The Cyclotron. Development of the cyclotron as initiated by Professor E. O. Lawrence of the University of California, had gone to the point where there were a number of such instruments available in American universities and in Europe and Japan, capable of producing beams of protons, deuterons, and alpha particles of energies of the order of ten million electron volts. At the time when the war interrupted such research there were 20 or 30 such instruments in use throughout the world, providing the essential means for production of artificial radioactive materials for chemical tracer studies and for basic studies of the physics of nuclear transformations.

Back in 1940, Lawrence had projected a much larger cyclotron to be built with a magnet having pole pieces 184 inches in diameter, which would produce a beam of particles having energies of the order of 100 million volts. This development was interrupted by the atomic bomb project when it was decided to devote this large electromagnet to the development of the mass spectrograph method of separating uranium isotopes already mentioned.

The giant cyclotron requires more than a mere scaling up of the smaller ones. The operation of an ordinary cyclotron depends on the fact that the period of revolution of a charged particle is independent of its energy: at higher energies it moves faster but moves in a larger circle, the speed and radius being proportional so that the period of revolution remains the same. Thus the alternating electric field which provides the acceleration means for the particles remains in phase with the revolving ions as they wind their way out from the center to the rim of the cyclotron chamber. But this result is only valid at energies sufficiently low so that the variation of mass with velocity is negligible. For the proton the energy equivalent of the rest mass is about 920 million electron volts. Hence, when a proton has an energy of 9.2 million electron volts, its mass has been increased by 10 per cent and a corresponding discrepancy results in the condition of synchronism of the particles with the alternating electric field which accelerates them.

One way to minimize this difficulty is to operate with the greatest possible voltage amplitude on the accelerating electrodes of the cyclotron. If the particle gets a large energy increment each time it crosses the gap, its whole trip will involve very few revolutions and there will be little opportunity for the alternating electric field to get out of synchronism with the revolving ions. However, this is not a very neat solution since high volt-

age operation of the radio frequency oscillators brings many special insulation problems and requires power losses that go up with the square of the desired voltage amplitude.

The Betatron. Another important development which came along just before the war was the practical development of the betatron by Professor D. W. Kerst of the University of Illinois. This now has been brought to the point where practical means exist for the production of a beam of electrons having energies of the order of 100 million volts, and still larger machines of this type are projected. In the betatron, the electrons are accelerated by the electric field associated with a changing magnetic field. For many years the general possibility of doing this was common knowledge among physicists, many of whom devoted a good deal of attention to the idea, but it remained for Kerst to get the idea of a means for utilizing this principle in a practical device.

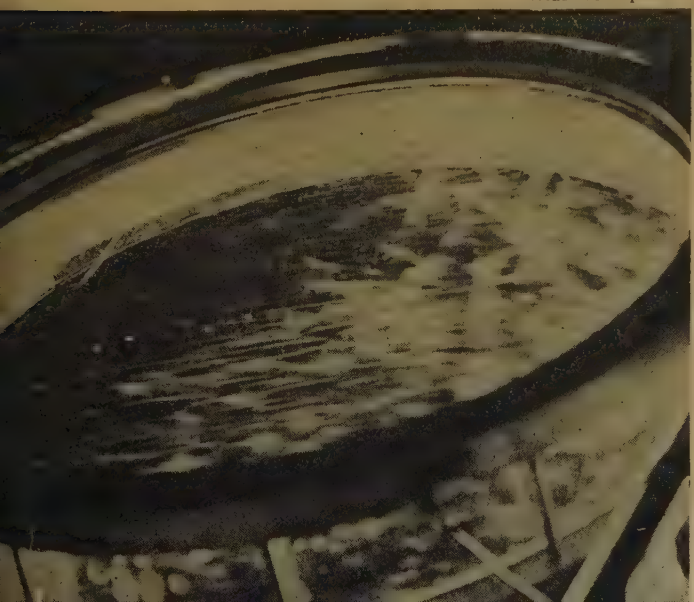
Considering that the rest energy equivalent of the mass of an electron is only half a million electron volts, it is plain that the betatron provides us with electrons whose energy is so great that their mass is some 200 times the mass of ordinary slow electrons such as we encounter in commercial electronic devices.

The Synchrotron. During 1945 some new ideas were introduced into this field which give us a broader conception of its possibilities than hitherto was realized. Corresponding to the truly international character of scientific advance, the important ideas seem to have occurred quite independently in Russia to V. Veksler and in America to E. M. McMillan of the University of California. McMillan calls the device a synchrotron. Its application to the acceleration of positive ions is being called a frequency-modulated cyclotron. Besides we have the betatron, and Pollock of the General Electric Company has shown how the betatron and synchrotron principles can be combined in a single machine for electron acceleration.

Briefly it may be stated that McMillan has shown that, in a device of the general type of a cyclotron or a betatron in which the particles move approximately in circles or spirals and are acted on by an alternating electric field, the most effective mode of operation is to work with the ions which are in nearly equilibrium orbits, that is, those which have such an energy that the orbital frequency is the same as that of the alternating electric field, and whose phase is such that they cross the accelerating gap just as the electric field is zero and changing in the sense that earlier arrival of the particle would result in acceleration. Such equilibrium orbits are stable in phase in the sense that a particle lagging behind tends to be accelerated and one running ahead tends to be decelerated. The position of the orbit in space may be stabilized by arranging matters so that the magnetic field falls off slightly with motion out from the center, so that the lines of magnetic force are concave toward the center.

Figure 2. Vapor trails produced by cosmic rays passing through a cloud chamber

Wide World photo



Particles in such equilibrium orbits are moving then in a manner which is stable in phase and in space. To accelerate the particles it is necessary to change the energy of such equilibrium orbits, which can be done either by changing the magnetic field, as in the betatron, or the frequency, as in the frequency-modulated cyclotron.

It is not possible here to go into a more detailed discussion of these important new ideas. Suffice it to say that they have been tested on the small 37-inch cyclotron at Berkeley and found to work when the frequency of the oscillating circuit is varied by a mechanical rotating condenser. As a result the large 184-inch cyclotron is being built in accordance with synchrotron principles, which will result in the production of a beam of particles of several hundred million volts. Construction has advanced to the point where a beam is expected before the close of 1946.* The synchrotron principle of operation does not require such high voltages as in the usual cyclotron. Because the particles have phase stability, they may be accelerated quite gradually even though the total acceleration produces a considerable variation in mass, say of the order of 30 to 50 per cent. This permits the great simplification of using low power oscillating electric fields to produce the acceleration.

Besides the giant cyclotron at Berkeley, Calif., several other large frequency-modulated cyclotrons are now under construction, notably at Harvard University, at Columbia University, and at the University of Rochester. In consequence there soon will be quite good facilities for researches on the nuclear transformations produced by bombarding atoms with ions having energies of the order of 300 million electron volts, that is, about 20 times the maximum available in the cyclotron laboratories of prewar days, and 50 per cent more than the great amount of energy released in a single act of uranium fission.

Who knows what will come of such research? Here

* The machine is now in operation at Berkeley, Calif.

we are really on the frontiers of knowledge without the slightest idea of what kind of results are to be expected. All we know is that from past experience we can expect adventures in this new region to be at least as exciting as the exploration of lower voltages was in the two or three decades just closed.

At the National Bureau of Standards we have plans for the construction of a 100-million-volt betatron, and probably of a similar acceleration device for positive ions, in order that the bureau may continue to discharge its basic responsibility for the establishment of measurement techniques and of safety standards for workers in this field.

So far I have dealt with only devices of the broad cyclotron class in which the particles are brought repeatedly under the influence of the same accelerating electrodes by the deflecting action of a magnetic field. But considerable progress also is being made in the application of the war-born microwave and cavity resonator techniques to the development of linear accelerators whereby particles can be accelerated to high energies by traversing alternating fields phased in such a way that the field is always in a direction to accelerate the particle at the place where it happens to be. Noteworthy among major projects of this class is the one being developed by Professor L. W. Alvarez of the University of California. In this it is expected to attain an acceleration of 1 million electron volts per foot of length on a tube 40 feet in length, the ions being injected at an energy of 4 million volts obtained by the aid of a pressure-type Van de Graaff machine based on the design of Professor Herb of the University of Wisconsin.

URANIUM CHAIN REACTIONS FOR POWER

Two types of atomic bombs have been developed, both based on the use of atomic fission induced by fast neutrons, one employing plutonium, an element which does not exist in nature, the other employing essentially pure U-235 which has to be separated at great expense from the U-239 of nearly identical physical and chemical properties with which it occurs in nature.

The element plutonium, which has atomic number 94 and atomic weight 239, is produced in a uranium pile, the quantity production in this country being carried out in a great plant built for the purpose at Hanford, Wash. It first was demonstrated, on the University of Chicago campus less than four years ago, that a suitable arrangement of lumps of ordinary pure metallic uranium interspersed with pure graphite could be made to undergo a controllable slow neutron chain reaction. In this equipment a U-235 atom undergoes fission on absorption of a slow neutron. In so doing it falls apart into two new radioactive atoms of medium atomic weight which move apart rapidly but are brought to rest quickly in the solid, their energy appearing simply as heat to warm the uranium. The splitting U-235 atom also spills out several more neutrons. These diffuse in the graphite where they are slowed down and diffuse back into the uranium to cause the fission of more U-235 atoms. Some of the neutrons are lost by absorption by impurities, others escape through the walls; so that in the steady state, although several are released in each fission, only one produces another fission. Of those which do not produce fission, a certain number are captured by the U-238 atoms in such a way as to form U-239. This isotope of uranium is radioactive and soon disintegrates into Np-239, an isotope of neptunium, the element next above uranium in the periodic table. This in turn disintegrates spontaneously with the emission of a beta particle converting into Pu-239, an isotope of plutonium. Although itself radioactive, Pu-239 is comparatively stable and can be separated from the uranium lumps from time to time for use in atomic bombs.

These operations produce a vast quantity of heat per unit of plutonium formed, but in the war project this heat was not utilized. In order to do so it would have been necessary to solve the engineering problems associated with high temperature operation, as heat has no value as a power source unless it is supplied at a high temperature. In this field the most important research projects before us consist in the development of the most economical forms of this equipment in order that the heat may be utilized to drive heat engines for conversion to electric power.

With the organization of a Federal Atomic Energy Commission as provided by legislation passed by the last Congress, we may look forward to a vigorous research and engineering development of the power generating possibilities of the uranium chain reactions. In accordance with the policies formulated in that legislation as recommended by President Truman, the interim management of the project by the Army's Manhattan District already has started developments looking toward the study of the means of using atomic power for peacetime uses.

It would be wrong to raise false hopes that an economic millenium is at hand. We know that the cost of basic production of power in our economy is a small fraction of the total productive effort required, so that even if power suddenly became free at the primary generating points, it would not make such a vast change in the economic picture as some imaginative writers have supposed. Moreover, at present our knowledge is so uncertain that it is very difficult to predict what costs will apply to power from atomic fission. Naturally much will depend at first on arbitrary questions of accounting, such as the question whether the research costs are simply to be absorbed as governmental expense, or charged to the operations resulting from such research.

Although it is too early to speak very definitely of the probable future prospects for atomic power, there is every indication that power from this source will have an important effect on the economy of ship propulsion, and also on the power supply of communities which

have neither water power nor a convenient coal supply.

In any case this topic is one of the utmost importance to electronics. Fundamentally it belongs to electronics under the broad definition here adopted. In the narrower sense this field will require a vast amount of electronic instrumentation, because of the necessity of equipping these plants with completely automatic self-regulating control devices due to the fact that the great amounts of radioactivity generated in their operation make it impossible for workers to come near them. If we get an atomic power industry of the future, it will be largely electronic in character.

RADIOACTIVE TRACER STUDIES AND THERAPY

Before the war a considerable number of artificial radioactive substances were available in minute amounts, and chemists were beginning to develop the technique of using them in fundamental studies of the mechanism of chemical reactions, especially in biochemistry. Also they were finding application for these substances in a limited way in therapy of malignant tumors and leukemia, using their radiations in combination with special chemical properties to give a wider range of possibilities than is afforded by X rays or natural radium or radon.

During the war a considerable number more of such radioactive elements was discovered, so that today there are approximately 450 such radioactive isotopes known, including at least one for each of the chemical elements from atomic numbers 1 to 96. Moreover, the large densities of neutrons available in the experimental uranium pile at Oak Ridge, Tenn., and the large production piles at Hanford, Wash., as well as the large amount of radioactive fission products, have made available quantities of radioactive materials of many kinds that are hundreds and thousands of times greater than were obtainable before.

The Army's Manhattan District recently has made arrangements to conform to the policy of giving wide distribution of these radioactive materials to research workers. Announcement of details concerning availability of these materials for civilian research purposes finally was made in *Science* on June 14, 1946, and the materials are beginning to flow out to workers in various biological research centers.

Some of the accomplishments made with tracer chemistry are quite marvelous. For example, the entire chemistry of plutonium necessary for the design of elaborate separation plants was learned from studies made with an unweighably small amount of the material, its behavior toward various reagents being studied by following the radioactivity.

Probably C-14 is the most important of these elements from the standpoint of future possibilities for chemistry. This is produced by the action of neutrons on some nitrogen containing compound, the neutron entering the N-14 nucleus and knocking out a proton and thereby transforming it to C-14. Because the whole field of biochemistry and medicine is founded on the chemistry of carbon, there is no limit to the scope of possible application of this material in learning about animal and plant metabolism in health and in disease. Likewise the H-3 isotope, tritium, is of very general importance.

Other radioactive isotopes which are certain to find many important applications are the 14.3-day P-32, the 180-day Ca-45, the 47-day Fe-59, the 250-day Zn-65, the 53-day Sr-89, and the 8.0-day I-131, where the times are the characteristic half-lives of the element in question.

To this rapidly developing art, electronics is making important contributions in steadily improving the convenience and reliability of the equipment used for measuring the radioactivity of these tracer elements.

COSMIC RADIATION

The study of cosmic radiation began some 20 years ago when the researches of Millikan and his associates, principally Bowen, showed clearly that the agent active in causing ionization in the air was absorbed by the atmosphere and by water and was clearly coming from outer space, or at least the outermost layers of the atmosphere.

In the ensuing years this cosmic radiation has been the subject of a steadily increasing and fruitful range of studies. It has been found that the radiations consist of charged particles coming in from outer space, with energies of the order of several billion electron volts, that is, ten times the maximum energy in the most ambitious of the acceleration devices described in an earlier section. In arriving at this conclusion studies are made of the dependence of the cosmic ray intensities on the magnetic latitude, the entire earth behaving like a giant mass spectrograph to help us determine the energy of the incoming particles.

Among the most important discoveries of recent years from cosmic ray research is that there are in the cosmic radiation, as determined from the tracks they produce in a cloud chamber in a magnetic field, a new type of basic particle, called mesons, whose mass is about 200 times that of the electron, and therefore about one-tenth that of the proton. These particles apparently have but a transient existence and their role in the scheme of things is far from being well understood. Since the mass of the electron is equivalent to 0.5 million electron volts, it follows that the rest mass of the meson is equivalent to about 100 million electron volts. Therefore it is natural to suppose, although not certain, that particles accelerated to well above 100 million volts in the new giant synchro-cyclotrons now under construction will be able to give us a controlled yield of mesons with the aid of which we can learn where they fit into the scheme of things.

That is why physicists are so anxious to get accelerating machines which extend to this range of voltage: from cosmic ray studies they have clear indications in advance that important things are to be learned there.

Control of D-C Aircraft Generators

A. T. McCLINTON
ASSOCIATE AIEE

Physical integration of all the control elements normally associated with a d-c generator is the object of this proposed electric system. With a carbon pile regulator as the basic element, the other necessary elements are added to produce a relatively simple but dependable system.

THE many operational problems resulting from the use of several individual items of control equipment for aircraft generators make an integrated control system desirable. It is believed that by the indicated selection and arrangement of control items, a unified system can be constructed which will result in the following:

1. Simplified maintenance problems because of the provision for quick removal of the control elements for bench adjustment.

2. Improved operation arising from a system kept in better adjustment.

3. Reduction in weight and space requirements over that required with decentralized location of devices.

The control system proposed demonstrates that it is possible to build a control unit for aircraft generators that makes the following attainable:

1. Accurate control of the bus voltage by means of control of the system regulation. It is not necessary to rely upon proper regulator adjustment, use of certain generators, or accurately determined line drops.

2. Connection of the bus to the generator when, and only when, it can furnish power to the bus.

3. An automatic system.

4. Better division of the load.

The output of d-c generators in use at the present time in aircraft is controlled primarily by two elements, a regulator and a relay.

If proper consideration is given to the selection of these control elements and to the configuration of the generator control system, it should be possible to realize the following:

1. System regulation at the aircraft load bus should not be dependent upon the regulator characteristic and line drop but should be governed simply and effectively for any system.

2. Load division should be controlled accurately and readily and should not be dependent upon the proper balance of line resistances and regulator characteristics.

3. The operation of each generator, whether on a single or multigenerator system, should be automatic, thus requiring none of the pilot's or flight engineer's attention.

4. The design and arrangement of the various control elements should permit placing all of these elements into one control panel so that

(*a*). Servicing of the aircraft would be simplified.

(*b*). Possible faults in the control circuit can be determined readily and corrected.

(*c*). Setting of system voltage would be simplified.

5. The control system should allow bench adjustment of all components. The only adjustment necessary after the control unit is placed in the aircraft should be to set the system voltage.

In order to satisfy these requirements for system performance, the control elements have been set up as described in the following text.

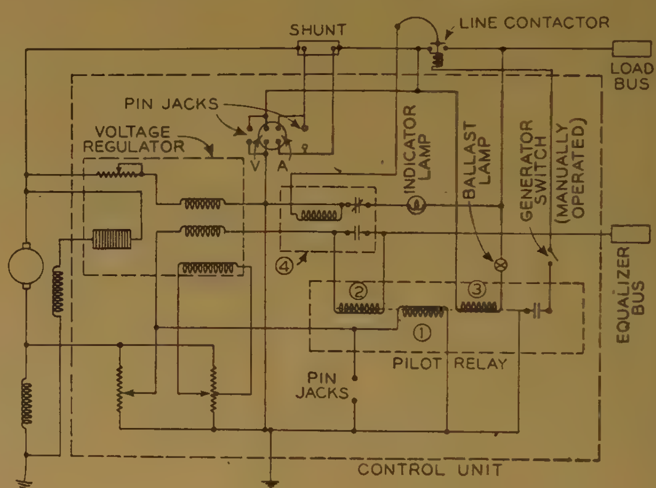


Figure 1. Schematic diagram of an integrated control system for use with single or multigenerator systems

1—Reverse current coil
2—Load differential coil
3—Voltage differential coil
4—Double pole relay

VOLTAGE REGULATOR

In order to accomplish the first two requirements for the control system, the voltage regulator should be able to maintain the same no-load voltage for all generators as well as to give approximately the same regulation for each generator comprising the system. If it were possible to obtain identical regulation for all generators, the problem of obtaining proper load division would be simplified greatly.

Essential substance of paper 47-14, "An Integrated Control System for Aircraft D-C Generators," presented at the AIEE winter meeting, New York, N. Y., January 27–31, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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Experience has demonstrated, however, that with present carbon pile regulators the regulation is dependent upon the setting of the regulator as well as upon the particular generator used. One other factor which must be considered is the voltage drop in the power leads

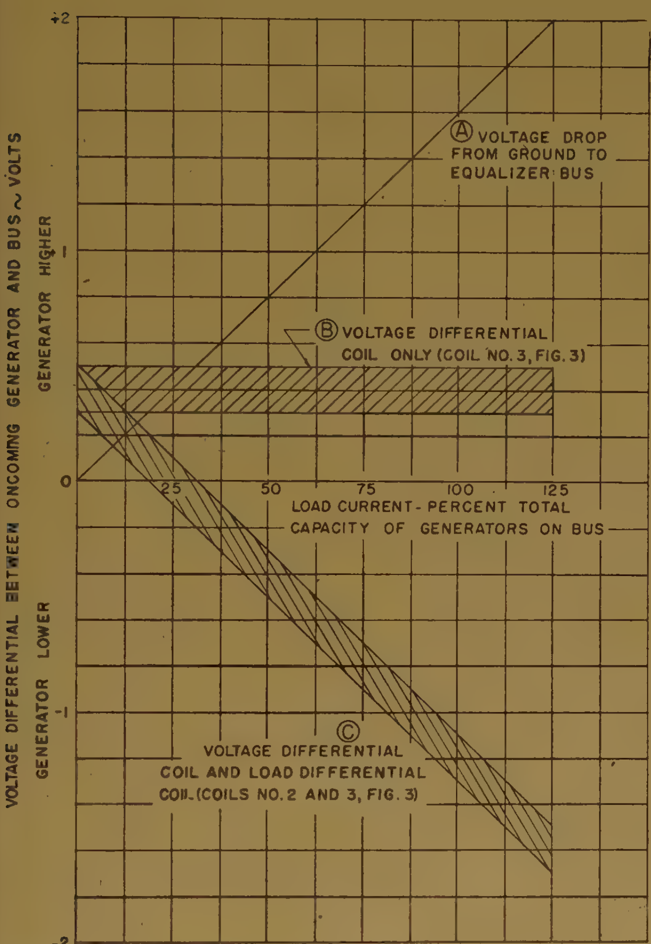

Figure 2. Closing characteristic of pilot relay when used with the integrated control system

from the point of regulation to the point of paralleling the generators.

UNIFORM REGULATION

As a means of providing uniform regulation which is independent of these factors, it is proposed that a carbon pile regulator equipped with a line drop compensating coil be used. Figure 1 shows a schematic diagram of this regulator and its connections to the rest of the system.

In addition to the line drop compensating coil and voltage coil, each regulator is provided with an equalizer coil which is wound in a direction such as to compensate for unbalanced loads between generators.

The selection of an equalizer voltage of 1.6 volts coupled with the high amplification of this equalizer circuit necessitates the removal of this coil from the equalizer bus when the associated generator is disconnected from the load bus. In the proposed system this was accomplished by inserting a relay in the equalizer circuit and connecting its operating coil between the armature of the double break line contactor and ground. Thus, when the line contactor is open, the equalizer control relay is de-energized.

PILOT RELAY

The pilot relay connects the bus to the generator when it can carry load, and disconnects the generator when it no longer will carry load. The model developed for use with the proposed system is a polarized device having two identical voltage coils and one current coil. The relay operates on a differential voltage principle, the two voltage coils giving the signal for closing, and the current coil giving the signal for opening the relay on reverse currents. Connections for this relay are shown in Figure 1. Because the load differential coil has a resistance of 20 ohms, the current in the equalizer coil circuit cannot decrease the bus voltage by more than 0.2 volt. This small change in bus voltage due to the pilot relay is of negligible magnitude.

The closing characteristics of this relay are plotted in Figure 2. *B* shows the closing characteristic of the pilot relay when only coil *3* is employed. It should be noted that the pickup characteristic of this coil is independent of the load on the aircraft bus. When coil *2* is also connected, the characteristic of the pilot relay is dependent upon the system load, as shown by the resultant closing characteristic, *C*.

EQUALIZER COILS

The fact that the oncoming generator can have a voltage lower than the bus voltage at the time it is connected to the line brings up the question as to how this generator will be able to carry any of the system load. This is accomplished through the action of the equalizer coils.

In way of explanation, let it be assumed that the equalizer coil of a generator is connected to the equalizer bus, but the line contactor of this generator is open. If there is a load on the remaining generators connected to the bus, the current flow in the equalizer circuit will cause an increase in voltage of the generator off the bus (line contactor open) and will cause the voltage of all generators on the bus to decrease. This will result in a new value of voltage difference between the generator off the bus and the bus voltage. As long as the equalizer coils are able to produce a voltage differential which is numerically greater than the values on curve *C* for corresponding bus loads, the oncoming generator will take part of the bus load. In fact the equalizer characteristic is such that the slope of *C* can be increased greatly and still meet these requirements. An increase in the slope of this curve might be desirable in view of the

fact that, if the increase were accomplished, a generator could be paralleled with the bus at lower system loads for a given voltage difference between the oncoming generator and the bus. This can be accomplished by increasing the ampere turns of coil *2;* doubling it would double the slope of this curve.

The action of coil *1* is to open the pilot relay on reverse currents. This coil will open when the reverse current is equal to five per cent of rated generator current.

CONTROL UNIT

The required generator control unit, as shown on Figure 1, now consists of the aforesaid voltage regulator pilot relay, an equalizer control relay in addition to a combination voltmeter and ammeter, a generator switch, an indicator lamp for signaling when the generator is disconnected from the load bus and pin jacks. These elements are mounted in one box which can be mounted in the control panel of the aircraft. The ballast lamp is inserted in series with the voltage differential coil to protect this sensitive coil from high reverse voltages. The 50-millivolt shunt and the line contactor are located external to the control unit to avoid the necessity of running the generator current through the control unit.

LOAD DIVISION

To demonstrate the capabilities of the proposed system to divide the load properly between generators, several tests were made involving different values of line resistance and different size generators. The tests showed that good division would result from the use of this system of parallel operation. Figures 3a and 3b show results which are typical of a system employing this control unit, where the bus voltage has been adjusted to rise with increase in load. The positive line resistance from each generator to bus was 0.045 ohm and 0.07 ohm, respectively. Ground circuit resistance was approximately 0.001 ohm, and the regulator voltage coils were connected to the positive terminal of the generator.

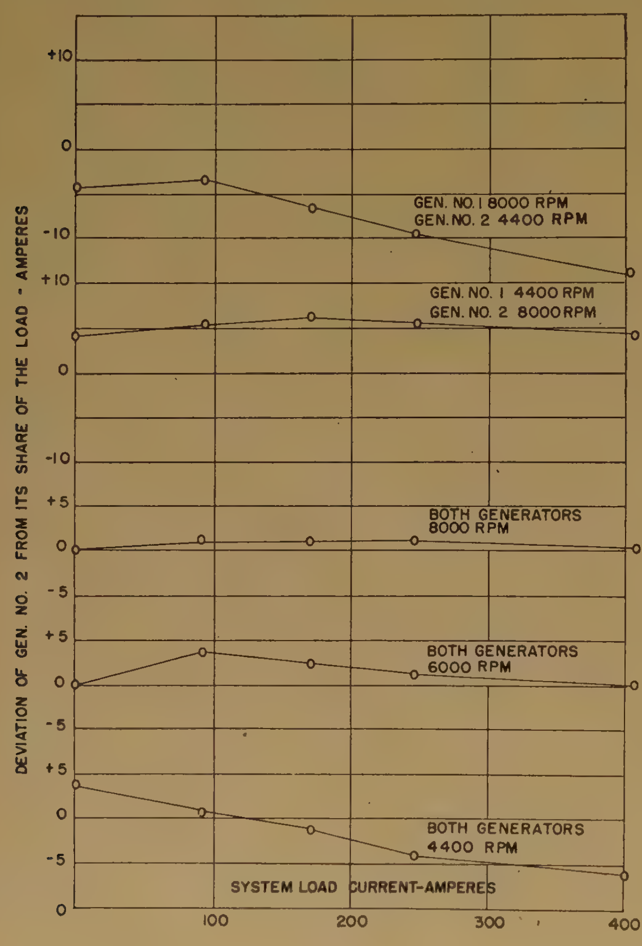

Figure 3a. Load division characteristics of a 2-generator system

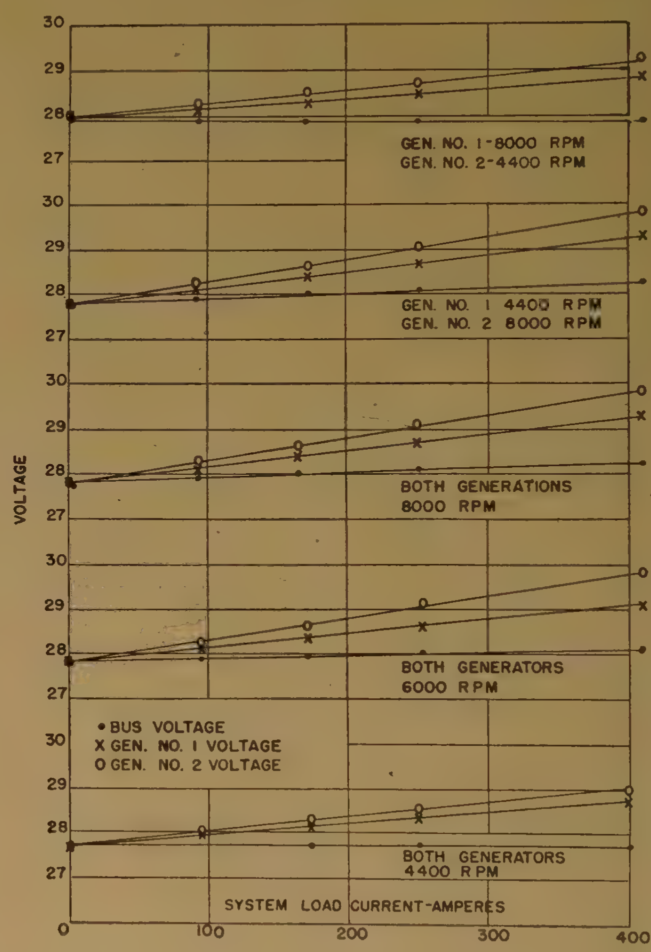

Figure 3b. System voltage characteristics of a 2-generator system

Radar Techniques in an Industrial Control

W. D. COCKRELL
MEMBER AIEE

The elementary electronics circuits familiar to radar men are not limited to one field, as is shown by this description of a typical industrial electronics application. Ultrahigh frequency techniques are described as used for register control in the printing and paper industries.

INDUSTRIAL electronics engineers and communications engineers long have felt that their circuits and techniques had little in common, that the one dealt with low frequencies and high power, whereas the other dealt with high frequencies and often with signals of extremely small power. However, with the development of such special communication fields as radar and loran, it has been found that many new circuits have been adopted in the communications field which are also quite useful in the industrial field. Therefore, it is highly desirable that the progressive electronics engineer in either field keep close contact with developments in the other so that he may take advantage of those which he may use best. Circuits such as square wave circuits, clippers, and blocking, timing, and counting circuits normally associated with radar have an equally important place in industrial electronic circuits. In fact, the side-register control circuit here described was designed before the war and before the present radar circuits were made available to the industrial engineer.

A TYPICAL INDUSTRIAL APPLICATION—PHOTOELECTRIC SIDE-REGISTER CONTROL

In the paper and printing industry, on slitting and processing machines where an accurate alignment of a web or strip is required, it is very desirable that the strip be wound or unwound so that the edge or a line of printing on it shall follow an exact path. Such a machine is shown in Figure 1 in actual operation. The basic mechanical operation may be seen more clearly from the simplified sketch. The photoelectric scanning head views the strip edge or a printed line. Any deviation from the correct path is signaled to the electronic control panel to excite an amplidyne generator. The amplidyne drives a correcting motor which moves the feed roll sidewise to correct the register of the strip.

THE PHOTOELECTRIC SCANNER

Because the most sensitive photoelectric tubes change their characteristics slowly over a period of time, it is desirable to operate on a sudden change of light, rather than on a continuous amount of light. To obtain a sudden change of light reaching the phototube, as reflected from the printing or edge of web, an optical system of four lenses mounted on a rotating disk is used. The image of a lamp filament is projected through the lens onto the paper, and as the lens moves this small spot of light describes a quarter circle. Figure 2 shows a typical unit and its schematic diagram. As the rotor of the small synchronous motor turns in accord with the electric voltage wave form, the position of the spot at any instant is directly related to the instantaneous value of the electric voltage driving the motor. Therefore, as the spot sweeps past the change in color corresponding to the register point, the change of the signal to the phototube may be matched in time with the instantaneous value of the alternating voltage. In this way, a corrective action may be set up if the register point is not in its correct position. The photoelectric scanning head including the optical system and tube is set up so that the correct register position corresponds approximately to the midpoint of the light arc. The principle of determining accurately the arrival of an electric pulse is the fundamental of radar. Although here such extreme accuracy is not needed, times before, as well as after, the reference instants must be determined.

The use of the rotating-lens optical system to operate a reversing motor on an on-off basis is not new, but the circuits developed to provide a signal proportional to the direction and amount of misregister do involve a number of radarlike circuit elements. A previous system provided only that if the light spot occurred earlier or later than a critical phase angle the correcting motor would be driven in a forward or reverse direction. However, inherent hunting action caused excessive wear on the correcting mechanism and was not completely satisfactory. A circuit was needed which could apply a correction nearly proportional to the distance away

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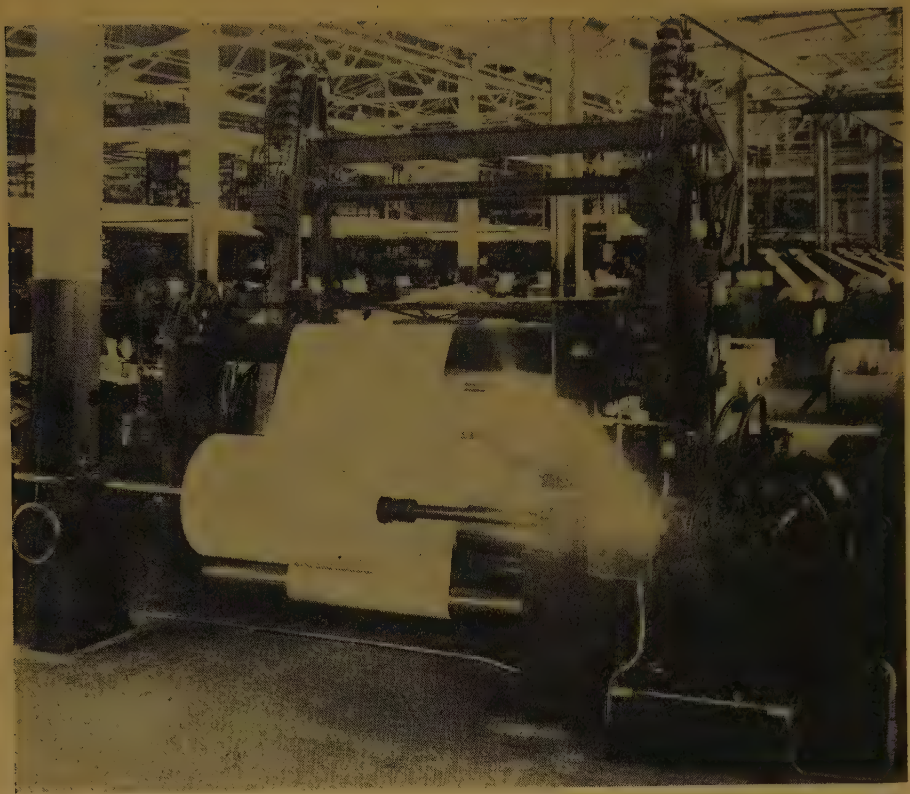
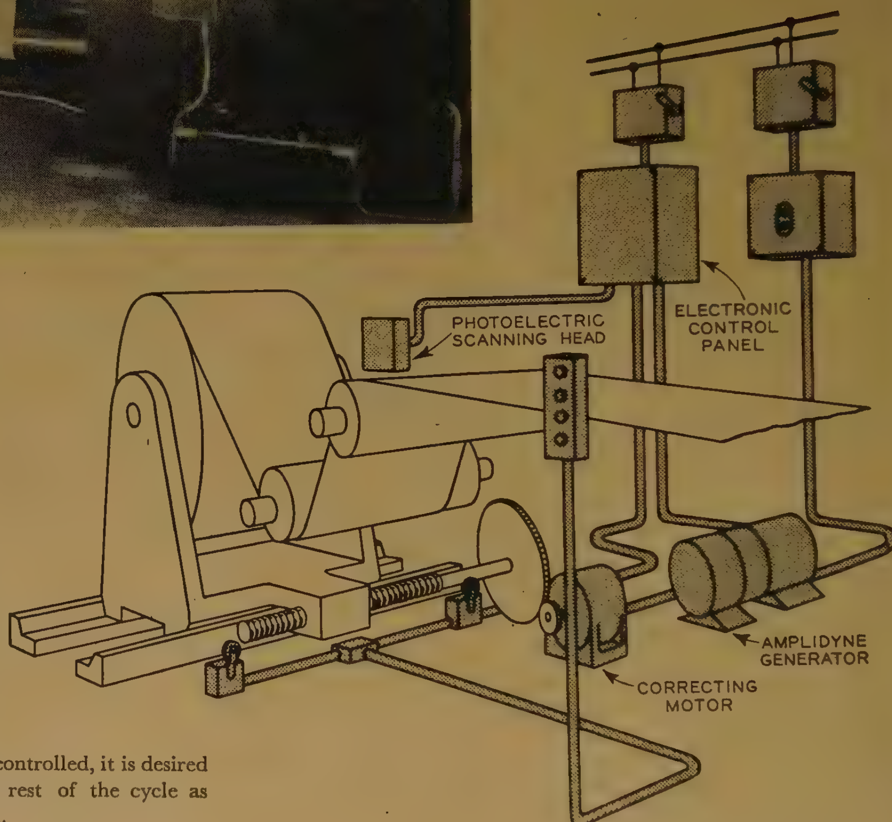


Figure 1. Aside-register control system



from register so that the corrective action might be smooth and the motor might remain at standstill when no correction was needed.

CIRCUIT REQUIREMENTS

A comparison must be made between

1. An amplified photoelectric tube signal which has a comparatively steep wave front at the instant the light spot crosses the edge of the material or the printed line which will be used for register. Since the width of the line is indeterminate, and the surface over which the light passes afterwards cannot be controlled, it is desired to eliminate the phototube signal for the rest of the cycle as soon as the register signal has been obtained.

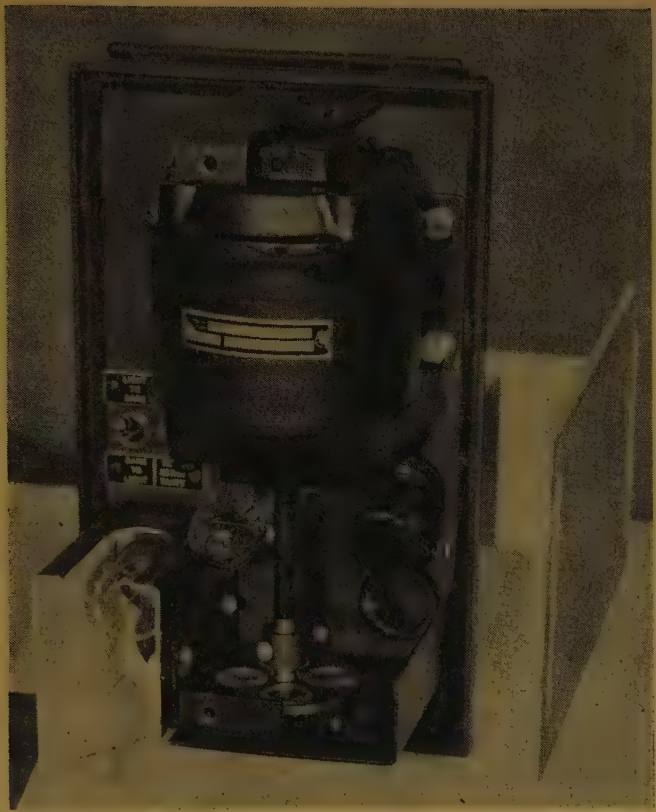
2. The instantaneous value of the sine wave voltage which is indicative of the position of the moving light spot.

The first step is to change the phototube signal into a uniform pulse and to eliminate all of the undesirable signals which the tube may pick up.

INPUT AND PULSE-FORMING CIRCUIT

To transform the somewhat indefinite signals coming in from the phototube amplifier into a consistent signal, they are first used to trigger a square-wave or "gate" circuit (Figure 3). This circuit consists of a twin triode tube *3V* with common cathode resistor *11R*, and with the grid of the second triode driven from the anode of the first by a voltage divider *13R* and *14R* to provide snap action from full current to cut-off whenever the first grid passes a critical voltage. Switches are provided in the photoelectric amplifier so that the triggering signal is always in a positive direction.

The Circuit Action—The Signal Trips. Before the circuit is tripped, triode *3AV* is normally nonconducting while triode *3BV* is conducting with zero grid voltage. When a positive pulse is applied by the photoelectric tube amplifier to the grid of the first tube through the capacitor *4C*, the first tube *3AV* begins to conduct; its anode potential is drawn toward that of the cathode;



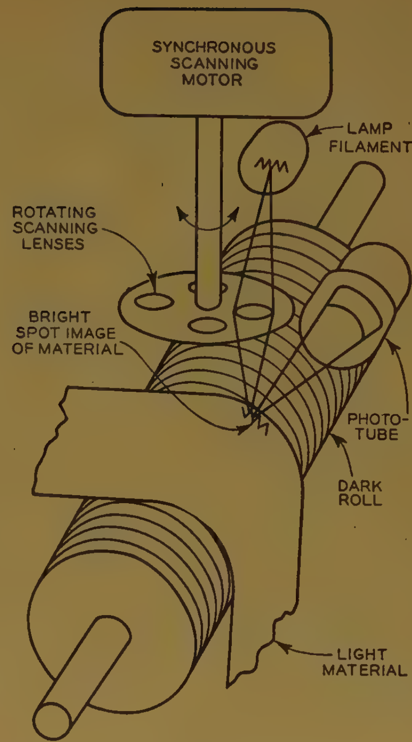


Figure 2. A photoelectric scanner with rotating lens system

and the grid of the second tube, through the voltage divider *13R* and *14R*, is driven sharply negative cutting off the second triode. The cathodes fall in potential permitting full current to flow through triode *3AV*. This instant in the operating cycle is shown at point *A* in the oscilloscope traces above the circuit diagram of Figure 3.

The grid of tube *3BV* is driven well negative below the *3AV* grid return point *40* so that no further action of the photoelectric amplifier will be effective to cut off the first tube. If the signal from the photoelectric amplifier should go far negative, as shown in the oscilloscope trace, the rectifier element of *4AV* limits the voltage to near point *40* and prevents any further negative swing.

Circuit Resetting Means. An alternating voltage obtained from the transformer *2T* and the phase-shift circuit *13C* and *44R* which provides a sine wave of the proper magnitude and phase is used to prepare the circuit for the next cycle. Rectifier *4BV* is so connected that during the positive part of this sine wave, *4BV* is not conducting and the reset circuit is disconnected. However, as this reset voltage swings negative (as it does near the end of the light-beam sweep) *4BV* conducts and so draws the grid of *3AV* far negative. This stops *3AV* from conducting and resets the circuit. Furthermore, so long as the reset voltage is negative, *3AV* cannot conduct and signals from the phototube remain ineffective until the reset voltage again swings positive and releases the *3AV* grid. Point *B* on the oscillograph traces indicates the beginning of the reset time.

THE PULSE OR "PIP" CIRCUIT

The desired signal for the indication of the instant of tripping is a very sharp pulse of positive voltage. This is obtained by coupling a very small capacitor to the anode of tube *3BV* so that the output plate of the capacitor will be drawn quickly positive when the tube *3BV* stops conducting, but will rapidly recharge to its original condition. The output signal from this portion of the circuit consists of a single uniform pulse, accurately timed to the passage of the light spot past the paper edge or register line. This occurs once each electric cycle.

ERROR DETECTION CIRCUIT

In this circuit (Figure 4), the instant of passage of the light spot past the register line (as indicated by the uniform pulse) is compared with the relative position of the light spot in its sweep (as determined by the instantaneous value of the voltage driving the synchronous motor). The relation between the voltage wave and light spot may be preset by the location of the lens disk on the motor shaft.

In practice, a 90-degree arc of movement is used. The scanner motor operates at 1,800 rpm, thereby allowing 1/2 cycle (at 60 cycles) for operation. In a properly phased sine wave, the voltage swings from a positive maximum through zero to a negative maximum.

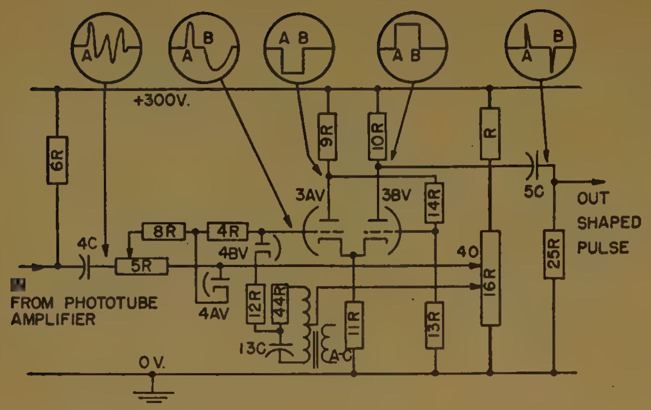


Figure 3. Input and pulse-forming circuits

Oscilloscope traces of typical wave forms at the points indicated appear at the top of the figure

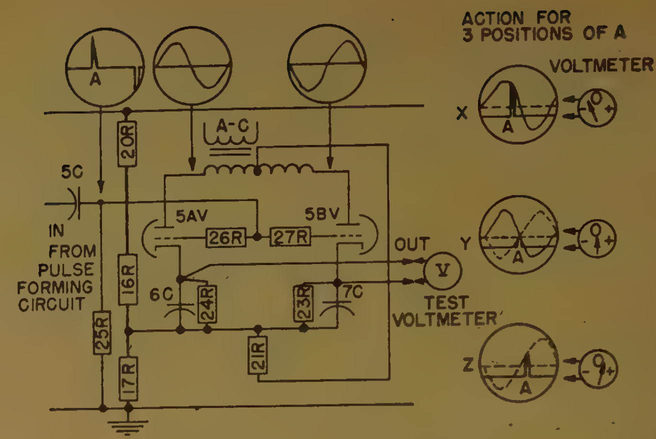


Figure 4. Error-detection circuit

X, Y, and Z illustrate three possible actions of this circuit and the corresponding voltmeter readings at the output terminals

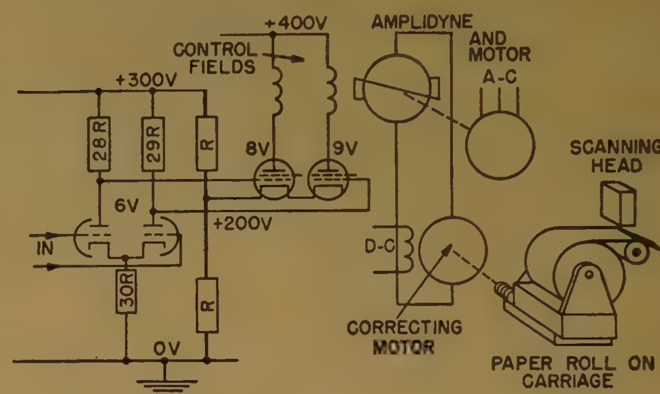


Figure 5. Output circuits and mechanical system

If this sine wave is applied to the anode of a tube and the pulse on the grid used to permit conduction at the proper instant, a brief surge of current corresponding to the instantaneous voltage applied will result. Thus, if the optical system is phased so that the correct register point corresponds to the zero voltage of the sine wave, a current will flow which is proportional both to direction and distance from register.

Because an electronic tube is a rectifier and cannot pass current in both directions two tubes *5AV* and *5BV* must be used; one is supplied with voltage from one phase, and the other from the opposite phase of the transformer. If the positive pulses are applied to the grids of both tubes, each cycle, only that tube which responds to the direction of error will conduct current.

THE PULSE-SMOOTHING CIRCUIT

In order to obtain a useful signal from the current pulses, they are used to charge two capacitors *6C* and *7C* of Figure 4.

The capacitor charges are drained off by shunt resistors, and as the current pulses arrive each cycle, each capacitor assumes an almost constant voltage proportional to the charge received. The output from this part of the circuit is taken from the positive plates of the capacitors.

The voltage between these leads is a comparatively smooth direct voltage, indicating both by magnitude and polarity the amount of misregister.

Output and Power Circuit. Once the misregister has been converted into a direct voltage, several means are available to provide power for the correcting motor. These include power electronic circuits, electromagnetic means, and the usual rotating exciters and d-c generators. In this particular application, an amplidyne (a fast-response generator, requiring low excitation power) will be assumed.

The two balanced control fields which excite the amplidyne are supplied by a pair of output pentode tubes (Figure 5). These, in turn, are fed by a balanced voltage amplifier whose grids are responsive to the capacitor potential indicating the misregister. This voltage-amplifier stage consists of a balanced cathode-follower circuit sometimes given the descriptive name "long-tailed pair," which is coming into widespread use to provide symmetrical deflection for the plates of the cathode-ray-oscilloscope tube used in radar, television, and many other fields.

CIRCUIT REFINEMENT

In an article devoted to the fundamental features of a circuit it is always desirable to eliminate those subordinate circuits which, while necessary in a practical design, tend to confuse a newcomer who wishes to trace the fundamental circuits. In the commercial equipment, there are rectifiers to supply direct current and filters for obtaining good wave form. Stabilizing or antihunt circuits are provided to obtain fast response with maximum circuit stability. Motor switches and protection are needed as well as push-button stations to permit manual operation of the correcting motor while setting up the equipment.

Equivalent Circuit of the Primitive Rotating Machine

GABRIEL KRON
MEMBER AIEE

Transient and steady-state performance of all standard rotating machinery used industrially can be determined by analyzing one generalized machine, the so-called "primitive machine." The tensorial method enables the engineer to ignore the internal processes of the rotating machine and to concentrate his attention upon the easily visualized external interconnection of the windings. The equivalent circuit of the primitive rotating machine with asymmetrical stator and rotor is derived using this method.

THE equations and equivalent circuits of all standard types of rotating electric machinery operating under arbitrary conditions may be derived as special cases of a single generalized rotating machine, the so-called primitive machine. The method of analysis is based upon the recognition that the transient and steady-state performance of all standard rotating machinery used in industry can be established by analyzing only one generalized machine whose physical and analytical study is comparatively easy. This is the primitive machine, exemplified by a synchronous or induction machine having several layers of windings on both stator and rotor.

First dealt with is the balanced primitive machine in which either the stator or rotor windings are balanced. There are two stator and two rotor windings assumed with one member having salient poles. In its equivalent circuit (Figure 1) the inductances represent the underlying magnetic circuit in which the fluxes flow, and the position of the resistances represents the arrangement of the coils on the magnetic circuit.

While the reactances are calculated at unit frequency, the fundamental frequency of currents along the stationary reference axes is assumed to be f, a fraction of unity. The numbers $f+v$, and so forth, by which the resistances and impressed voltages are divided, show the actual frequencies of the currents in the particular coils. (In commutator machines where the ratio of the generated to induced voltages as a result of a flux line is not unity but k, the rotor speed v should be replaced by kv.) The resultant flux linking each coil is the voltage E while the torque as a result of the coil is the power E^*i.

When both the stator and rotor windings are unbalanced (still assuming saliency on one member only) in the stator (or field) flow not only a current of frequency f, but also even harmonics of the rotor speed v, namely $f\pm 2v$, $f\pm 4v$, and so forth. In the rotor (or armature) flow in addition to f odd harmonics of v, namely $f\pm v$, $f\pm 3v$, $f\pm 5v$, and so forth.

For each frequency of stator and rotor currents there exists in the equivalent circuit of Figure 2 a set of forward and backward meshes that are coupled together by the unbalanced rotor (armature) impedances. The stator and rotor circuits are staggered and are coupled together through the air gap reactances. Again the numbers by which the resistances and impressed voltages are divided show the actual frequency of currents in the coil, such as $f-2v$ or $f+3v$. While the two stator reference axes are denoted by **d** and **q**, the two rotor reference axes along which the resistances and reactances are known are denoted by **a** and **b**. For an induction motor **a** and **b** are the slip-ring axes, and for a synchronous machine they are the armature axes.

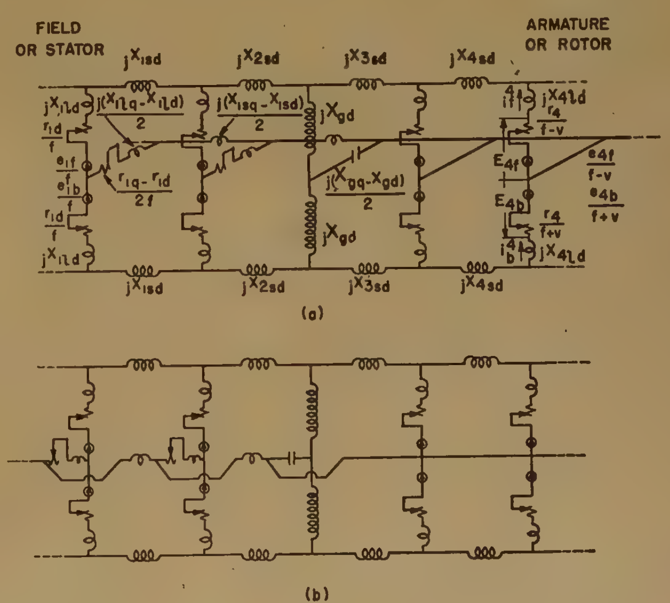


Figure 1. Two different forms of the equivalent circuit of the primitive rotating machine

Essential substance of paper 47-3, "Equivalent Circuit of the Primitive Rotating Machine With Asymmetrical Stator and Rotor," presented at the AIEE winter meeting, New York, N. Y., January 27–31, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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	$\bar{f}_{so}$	$\bar{b}_{so}$	$\bar{f}_{ro}$	$\bar{b}_{ro}$	$\bar{b}_{r2}$	$\bar{f}_{r2}$	$\bar{b}_{s2}$	$\bar{f}_{s2}$	$\bar{f}_{s-2}$	$\bar{b}_{s-2}$	$\bar{f}_{r-2}$	$\bar{b}_{r-2}$	$\bar{b}_{r4}$	$\bar{f}_{r4}$
$\bar{f}_{so}$	$\frac{r_{ds}+r_{qs}}{f}+j(X_{ds}+X_{qs})$	$\frac{r_{ds}-r_{qs}}{f}+j(X_{ds}-X_{qs})$	$2jX_S$	$2jX_D$										
$\bar{b}_{so}$	$\frac{r_{ds}-r_{qs}}{f}+j(X_{ds}-X_{qs})$	$\frac{r_{ds}+r_{qs}}{f}+j(X_{ds}+X_{qs})$	$2jX_D$	$2jX_S$										
$\bar{f}_{ro}$	$2jX_S$	$2jX_D$	$\frac{r_a+r_b}{f-v}+j(X_{Sa}+X_{Sb})$	$2jX_D$	$\frac{r_a-r_b}{f-v}+j(X_{Sa}-X_{Sb})$									
$\bar{b}_{ro}$	$2jX_D$	$2jX_S$	$2jX_D$	$\frac{r_a+r_b}{f+v}+j(X_{Sa}+X_{Sb})$		$\frac{r_a-r_b}{f+v}+j(X_{Sa}-X_{Sb})$								
$\bar{b}_{r2}$			$\frac{r_a-r_b}{f-v}+j(X_{Sa}-X_{Sb})$		$\frac{r_a+r_b}{f-v}+j(X_{Sa}+X_{Sb})$		$2jX_S$		$2jX_D$		$2jX_D$			
$\bar{f}_{r2}$				$\frac{r_a-r_b}{f+v}+j(X_{Sa}-X_{Sb})$		$\frac{r_a+r_b}{f+v}+j(X_{Sa}+X_{Sb})$		$2jX_S$		$2jX_D$		$2jX_D$		
$\bar{b}_{s2}$					$2jX_S$		$\frac{r_{ds}+r_{qs}}{f-2v}+j(X_{ds}+X_{qs})$		$\frac{r_{ds}-r_{qs}}{f-2v}$ $j(X_{ds}+X_{qs})$		$2jX_D$			
$\bar{f}_{s2}$						$2jX_S$		$\frac{r_{ds}+r_{qs}}{f+2v}+j(X_{ds}+X_{qs})$		$\frac{r_{ds}-r_{qs}}{f+2v}$		$2jX_D$		
$\frac{1}{2}$ $\bar{f}_{s-2}$					$2jX_D$		$\frac{r_{ls}-r_{qs}}{f-2v}+j(X_{ds}-X_{qs})$		$\frac{r_{ds}+r_{qs}}{f-2v}$ $j(X_{ds}+X_{qs})$		$2jX_S$			
$\bar{b}_{s-2}$						$2jX_D$		$\frac{r_{ds}-r_{qs}}{f+2v}+j(X_{ds}-X_{qs})$		$\frac{r_{ds}+r_{qs}}{f+2v}+j(X_{ds}+X_{qs})$		$2jX_S$		
$\bar{f}_{r-2}$					$2jX_D$		$2jX_D$		$2jX_S$		$\frac{r_a+r_b}{f-3v}+j(X_{Sa}+X_{Sb})$		$\frac{r_a-r_b}{f-3v}+j(X_{Sa}-X_{Sb})$	
$\bar{b}_{r-2}$						$2jX_D$		$2jX_D$		$2jX_S$		$\frac{r_a+r_b}{f+3v}+j(X_{Sa}-X_{Sb})$		$\frac{r_a-r_b}{f+3v}+j(X_{Sa}-X_{Sb})$
$\bar{b}_{r4}$											$\frac{r_a-r_b}{f-3v}+j(X_{Sa}-X_{Sb})$		$\frac{r_a+r_b}{f-3v}+j(X_{Sa}+X_{Sb})$	
$\bar{f}_{r4}$												$\frac{r_a-r_b}{f+3v}+j(X_{Sa}-X_{Sb})$		$\frac{r_a+r_b}{f+3v}+j(X_{Sa}+X_{Sb})$

Equation 1

The torques still are measured as cross products of E^*i. The frequency of the latter is determined easily by simply matching the frequencies of E and i as manifested by the resistances in the respective coils. For instance, the actual frequency of E_{2f} is $f+v$ and of i^{-2fr} is $f-3v$. Hence, the frequency of the torque as a result of them is

$$\begin{aligned} T &= E^*i \\ &= -f-v+f-3v \\ &= -4v. \end{aligned}$$

The various types of machines, synchronous and induction, differ from the primitive machine by having certain meshes open. An example is the slip-ring induction motor in which the rotor is loaded unequally but is still smooth magnetically. For commutator machines the meshes are not only open but are interconnected in the same manner as the actual machine windings are. When certain windings in a machine are short-circuited permanently, the analogous meshes in the equivalent circuit may be removed, but all open-circuit reactances must be replaced by short-circuit (transient and subtransient) reactances. An example is the single-phase alternator. In the latter the mutual couplings between the various harmonics depend only on the asymmetry of the direct and quadrature axes.

The question now arises as to how these various frequencies of currents are produced. Let sinusoidal windings be assumed on stator and rotor, windings in which only a flux with the fundamental number of pairs of poles can induce a voltage. (This assumption neglects space harmonics and hence excludes squirrel cages.) In that case, higher time harmonics may be induced only by fluxes that rotate faster than the impressed flux. In

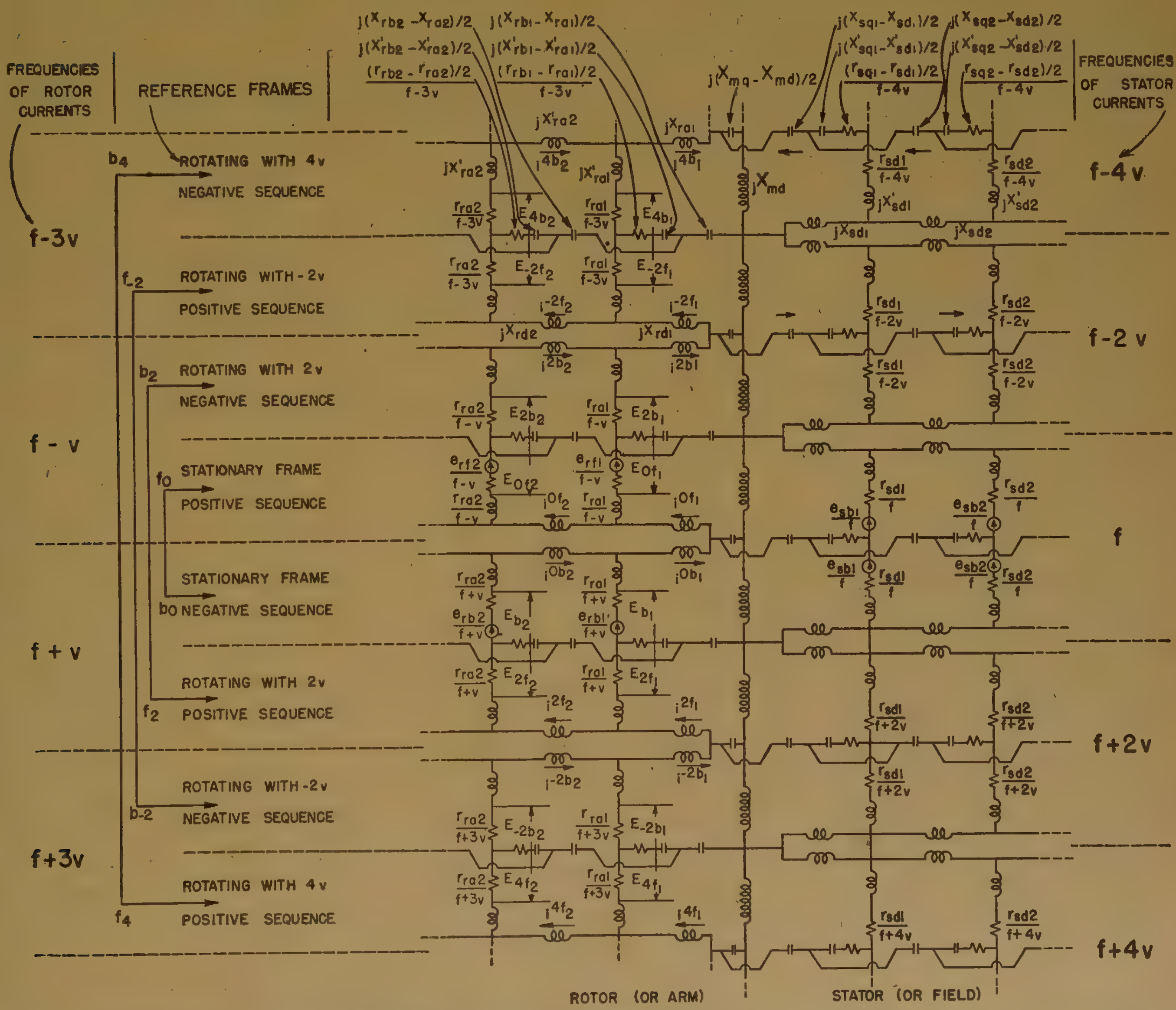

Figure 2. The primitive machine with unbalanced stator and rotor (for a synchronous machine v and i (or E) have opposite sign)

particular, these fluxes must rotate faster by $\pm 2v$, $\pm 4v$, $\pm 6v$, and so forth, than the fundamental flux when viewed from the stator (or faster by $\pm v$, $\pm 3v$, $\pm 5v$, when viewed from the rotor).

Hence, if an infinite set of reference frames are introduced rotating by $\pm 2v$, $\pm 4v$, $\pm 6v$, with respect to a set of reference frames stationary on both stator and rotor, then along these rotating reference frames the time harmonics under consideration must appear as fundamental frequency quantities.

Harmonic terms (sine and cosine expressions) along all reference frames are neglected and only the constant term kept.

Each of the above reference frames originates another infinite set of reference frames rotating with $\pm 2v$, $\pm 4v$, ...with respect to itself. Each of the latter in turn starts still an additional infinite set of frames. Consequently, along each frame rotating with $\pm 2v$, $\pm 4v$, and so forth, not one current exists, but an infinite set of currents. All of these, but one, are neglected.

The equations are set up and the equivalent circuits are developed by the methods of tensor analysis which may be looked upon as an extension and generalization of vector analysis from 3-dimensional to n-dimensional spaces and from Euclidean to various types of non-Euclidean spaces. The tensorial method, based upon the concept of "transformation of reference frames," enables the engineer to ignore the internal processes of the rotating machine, the cutting of fluxes, and inducing of voltages, and restricts his attention only to the easily visualized external interconnection of the windings.

Starting with the equations ($\mathbf{e} = \mathbf{Z}.\mathbf{i}$) of the primitive rotating machine along stationary axes, three transformations are introduced in succession to establish the equivalent circuit.

1. One set of stationary and three sets of rotating axes are introduced on each structure.
2. Forward and backward rotating (hypothetical) axes are introduced along each set of frames.
3. The frequencies are changed to fundamental frequency.

Each of these transformations is performed in a routine manner with the aid of a transformation matrix $\mathbf{C}$. The resultant equations are again of the form $\mathbf{e}' = \mathbf{Z}'.\mathbf{i}'$. The resultant impedance tensor $\mathbf{Z}'$ is given in equation 1 of this article.

Multiplex Broadcasting

Pulse Time Modulation and Its Application to Radiobroadcasting

F. ALTMAN J. H. DYER

MULTIPLEX BROADCASTING is the simultaneous transmission of several programs from a single transmitter and antenna. This system is of timely interest as it offers a logical solution to some of the difficulties encountered as future broadcast channel allocations are forced toward the microwave region of the radio spectrum.

Problems such as line-of-sight transmission, interference due to reflections, and technical and economic problems of microwave circuit construction, all of which are inherent to high frequency operation, are reduced or turned to advantage if multiplex instead of conventional simplex operation is employed.

Of the advantages gained through multiplex operation, one of major importance is that a centrally located transmitter at the highest point of the service area gives equal coverage to a number of broadcasters and eliminates costly duplication of transmitter and antenna sites.

From the standpoint of the broadcast listener, certain important advantages are gained through multiplex operation. At the receiving location no radio-frequency tuning is required as a common frequency is used for all programs. A fixed-tuned receiver therefore may be used. Furthermore, antenna problems are reduced since a single fixed directive antenna of maximum efficiency may be used for receiving all programs.

With simplex broadcasting, however, station tuning is always necessary, and antenna rotation may be required for each program. At high frequencies directional receiving antennas are needed for maximum efficiency and the elimination of interference from multipath reflections.

An additional advantage of the multiplex method is the simplicity of relaying in nationwide hookups. Instead of the present telephone line relaying of individual

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programs, the entire multiplexed series may be beamed over common links connecting the various cities in the hookup.

The increasing demands for space in the radio spectrum have forced the Federal Communications Commission and the radio industry to search for new means and methods of allocating and utilizing radio channels. The pulse-time-modulated time-division-multiplexed system offers a solution to the problems encountered in broadcasting at ultrahigh frequencies.

MULTIPLEXING

The principle of multiplexing is not new, but in the past has been confined to telegraph circuits and telephone transmissions. There are two basic types of multiplexing: frequency division multiplex and time division multiplex.

Frequency Division Multiplex. Exemplified by the type *K* carrier system, frequency division multiplex consists of modulating a series of discrete subcarrier frequencies with a corresponding set of audio-frequency signals, so that each program occupies a separate band of frequencies.

These frequencies then are added together to form a complex signal which may be used to modulate a suitable radio-frequency carrier by any one of the conventional means, namely, amplitude modulation, frequency modulation, or phase modulation. A fixed-tuned receiver receives the complex signal in a conventional manner and separates the individual frequency bands which carry the individual programs by means of a variable frequency tuner in the intermediate frequency stage or by channeling them through frequency selective filters. Final demodulation is accomplished by conventional means. Figure 1*A* illustrates this type of multiplexing.

Time Division Multiplex. Time division multiplex is a discontinuous method of combining individual audio-frequency signals. That is, fragments of each program are transmitted in rapid succession with only one program modulating the carrier at any given instant of time, as opposed to the continuous method of processing used in frequency division multiplex. Time division involves a series of pulses having a duration which is very short compared to the time spacing between successive pulses. Each group corresponds to the individual signals or programs. By controlling the timing of the several pulse sequences, several groups may be interleaved to form the multiplexed series. A characteristic marker pulse series also is interleaved for synchronization in the receiver. Figure 1*B* illustrates this type of multiplexing.

The repetition rate of the pulses is chosen to be approximately two and one-half times the highest audio frequency to be transmitted in each channel. Because of this rapid sampling of programs, no appreciable change in the audio-frequency signal occurs between two successive pulses of a given series; hence the audio-frequency components are transmitted with full fidelity.

Choice of Multiplexing. The technical requirements

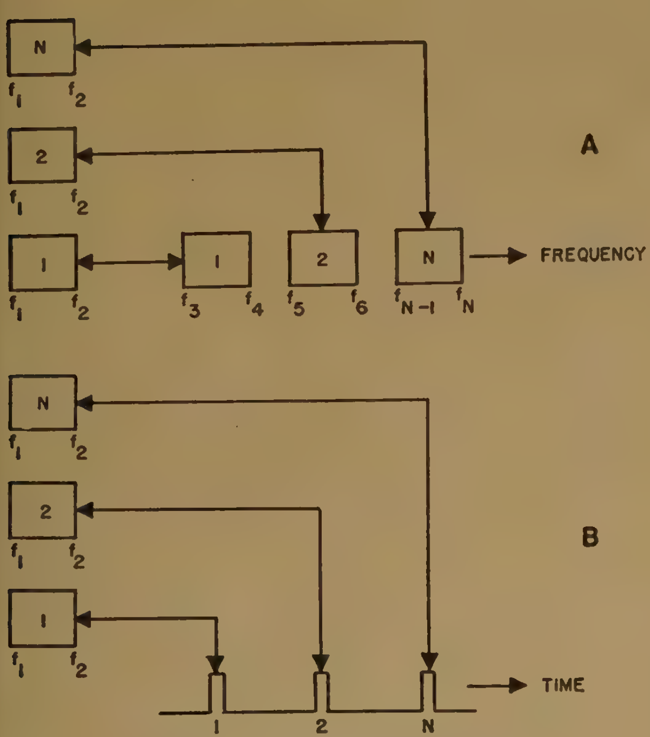

Figure 1. Multiplex transmission

A—Frequency division multiplex B—Time division multiplex

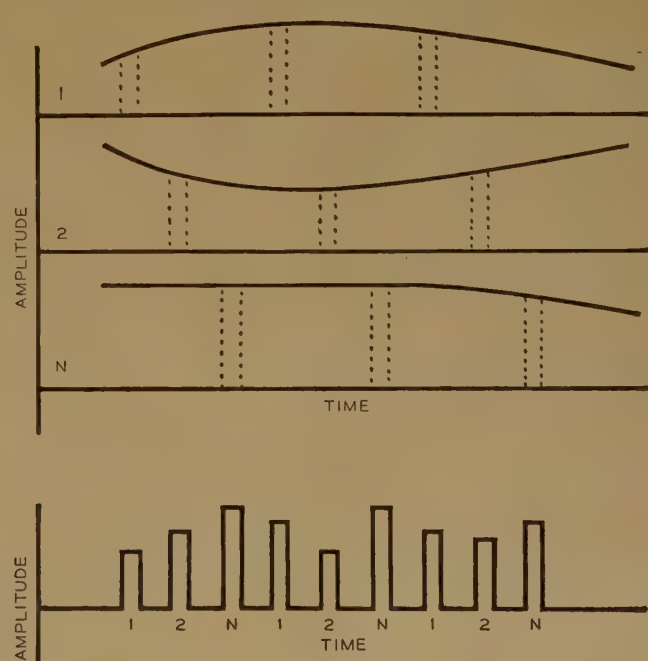

Figure 2. Formation of a time division subcarrier from several audio signals

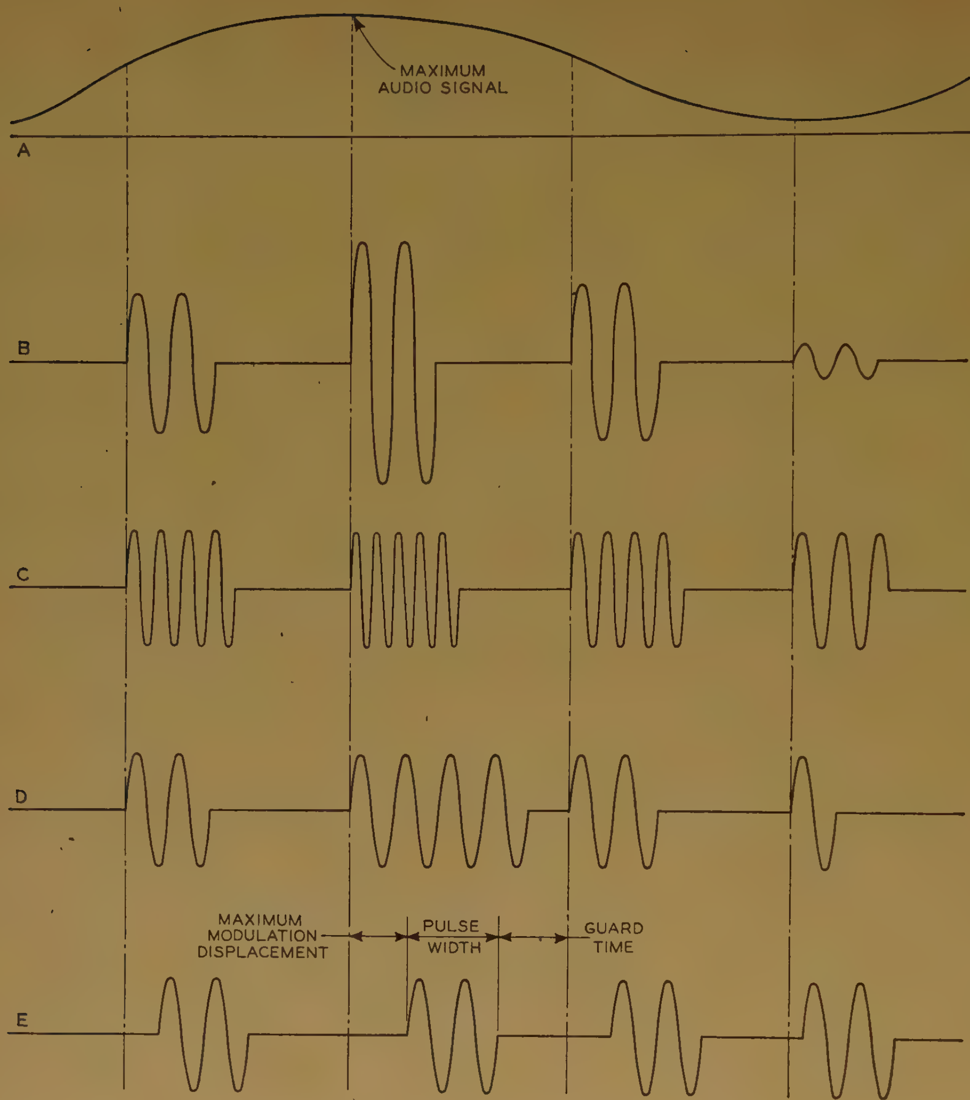

Figure 3. Various methods of modulating a time division multiplex carrier

Only one audio channel is shown, in practice other channels would be interleaved among the pulses shown

A—Audio signal
B—Amplitude modulation
C—Frequency modulation
D—Pulse width modulation
E—Pulse time modulation

for both systems are, of course, a sufficient frequency band to accommodate the total number of desired channels. Frequency division multiplex requires in addition an extreme degree of circuit linearity at both the transmitter and receiver in order to avoid undue cross talk and cross modulation conditions, as well as the necessity for frequency tuning or filtering in both transmitter and receiver. Time division multiplex eliminates this linearity requirement because each channel is transmitted at a different time. The expense involved in achieving the required transmitter performance in any system is not of major importance, but such expense is of paramount importance in the receiver.

Methods of Modulation of Time Division Multiplex. As in frequency division multiplexing, the complex pulse sequence may be used to modulate a radio-frequency carrier by any of the usual methods.

Amplitude modulation may be obtained by applying the subcarrier voltage (Figure 2*B*) to one grid of a multigrid tube and the carrier voltage to another grid. Or the subcarrier voltage may be applied to the plate of a triode and the carrier voltage used to control the grid. Figure 3*B* illustrates an amplitude modulated wave carrying one signal. In practice other channels appear in the gaps between the illustrated pulses. A time interval between adjacent pulses is maintained to decrease interchannel cross talk.

Figure 3*C* shows a single-channel frequency-modulated time-division-multiplex signal.

Pulse-width modulation carries the intelligence in the varying durations of the transmitted pulses. Their constant amplitude makes the received signal independent of vagaries in the transmission path. However, this method causes the transmitter to operate at variable power. It may be accomplished generally in the same manner as pulse time modulation, explained subsequently, except that the position of only one edge of the pulse would be varied by the signal to be transmitted, thereby producing pulses modulated in width instead of time position.

Several other systems of modulation have been proposed. For example, the modulation may consist of varying the space between a pair of pulses. Since such a system would require two pulses per channel, the number of channels possible would be greatly reduced. A pulse-number modulation has been suggested which would transmit successions of short pulses, the number of pulses being dependent upon the amplitude of the modulating signal.

Although it is possible to modulate the pulses in amplitude or width, the full advantages of time division multiplex are gained by utilizing pulses of constant amplitude and translating the amplitude variations of the signal into time or position displacement of the successive pulses with respect to the position of a marker pulse.[2]

In pulse time modulation the dynamic amplitude change of the modulated signal results in a corresponding time displacement of the pulse and the rate of change of dynamic amplitude or frequency controls the rate of change of displacement of the successive pulses in the sequence. Figure 3*E* illustrates pulse time modulation.

Specific advantages of pulse-time time-division multiplexing are

1. Simplification in combining channels at the transmitter and separating them again at the receiver by eliminating the need for relatively complex filters.

2. Maximum transmitting efficiency is obtained since the intelligence is converted to a sequence of constant amplitude pulses having very short duration for keying the transmitter. The transmitter therefore is turned off most of the time so that high peak powers are obtained for correspondingly low average power. This also results in considerable simplification of the comparable subcarrier circuits in both the transmitter and receiver.

3. By eliminating the necessity for tuning there is considerable reduction in stability requirements of the receiver.

4. Improved cross talk characteristics can be obtained simply by providing the proper frequency bandwidth without necessitating elaborate circuit precautions at both transmitter and receiver in order to assure amplitude and phase linearity. This is because in time division multiplex only one signal is sent at any instant of time.

5. Pulse time modulation offers additional possibilities for improving signal-to-noise ratio because it is a wide band system and limiters and other noise reducing devices may be utilized effectively.

6. If repeaters are used for extending the range of transmission, the inherent discontinuous characteristic of pulse time modulation permits simplification in the repeater system and greatly reduces cumulative effects of noise, cross talk, and distortion which are present in other methods of transmission.

EIGHT-CHANNEL PULSE TIME MODULATION MULTIPLEX BROADCASTING SYSTEM

Early in September 1946, International Telephone and Telegraph Corporation demonstrated for the first time an 8-channel broadcast system developed by its research associate, the Federal Telecommunication Laboratories, Inc. In the demonstration equipment each channel had a uniform frequency response up to

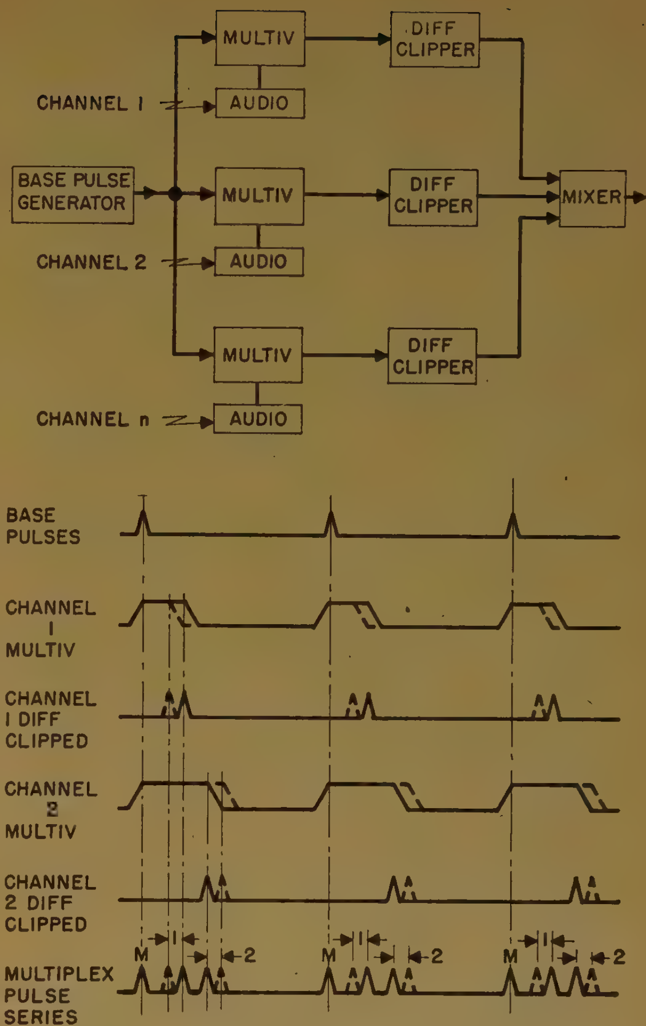

Figure 4. Multiplex modulator, multivibrator type

nine kilocycles and the transmission bandwidth was approximately six megacycles at a radio carrier frequency of 930 megacycles.

The PTM multiplex broadcasting system is composed of the following major units:

1. Multiplex modulator.
2. Radio-frequency transmitter.
3. High gain omnidirectional transmitting antenna.
4. High gain directive receiving antenna.
5. Receiver.

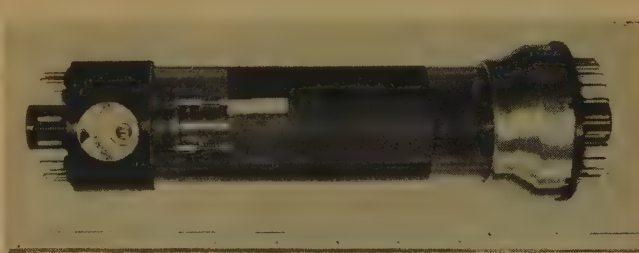

Figure 5. Cyclophon tube

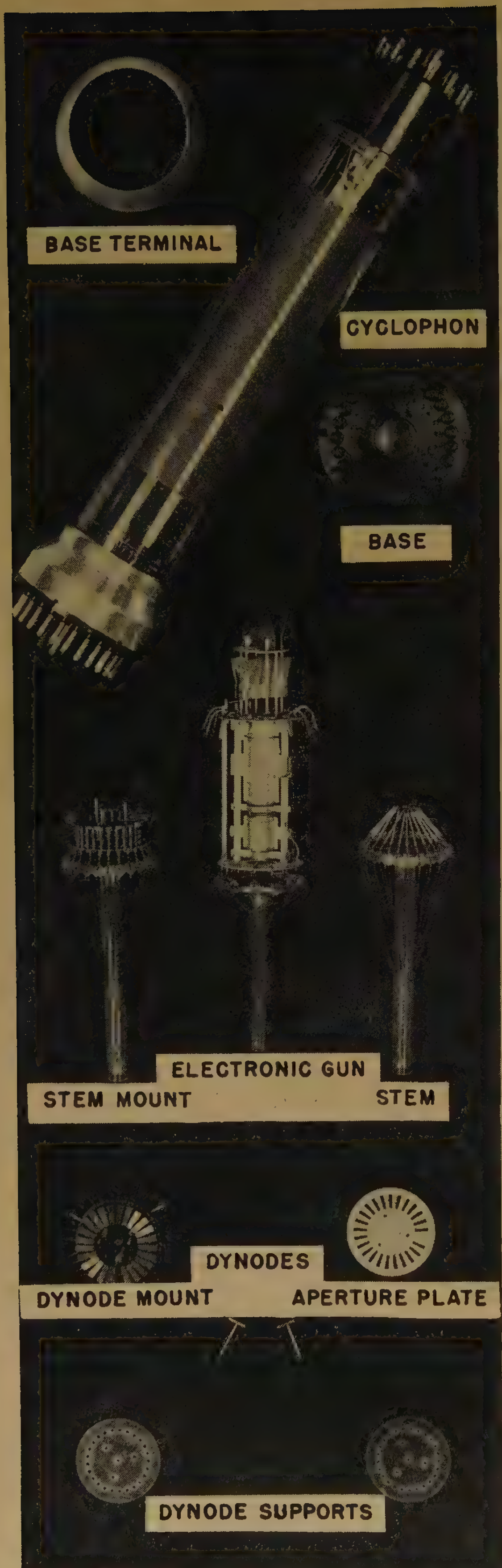

Figure 6. Component parts of the Cyclophon tube

Modulator. In general the modulation process can be divided into the following steps:

1. Generation of channel pulses at proper time intervals for each channel.
2. Limitation of the audio-frequency modulating signal to prevent cross talk or "break-through" between channels.
3. Modulation of each series of channel pulses by the respective audio-frequency signal.
4. Generation of a marker pulse.
5. Final mixing of channel and marker pulses into one interleaved set.

Modulation may be obtained with the use of standard ultrahigh frequency circuits. One method uses a series of multivibrators, one for each channel and a separate generator for the marker. Each pulse series is timed by adjusting the circuit constants of the multivibrator. Modulation is introduced by controlling the width of the output pulses. These width-modulated pulses are converted to a time-modulated series by the use of a differentiating and clipping circuit (Figure 4).

The multiplex modulator used in the demonstration consists of the following basic sections: saw-tooth generator, delay line synchronizer, audio amplifier (one for each channel), marker pulse shaper, and mixer shaper.

The 9,000-cycle audio fidelity* is assured by the use of a 24-kilocycle saw-tooth pulse generator, and the basic timing of the pulse channels is obtained by a series of stable time delay elements, tapped at nine successive points. By this method, nine pulse sequences are produced, each having the basic 24-kilocycle repetition rate, but displaced from the marker sequence by a different time interval.

Eight saw-tooth pulse sequences are fed to the corresponding time modulators of each program channel where they are converted to rectangular pulses varying in time displacement. Basically, this is accomplished by clipping a wedge from the saw-tooth pulse at an amplitude proportional to the instantaneous value of the audio signal. The resulting series of width modulated pulses then are differentiated and clipped to produce a sequence of time modulated pulses of constant width, corresponding to the leading edges of the width modulated pulses.

The other saw-tooth sequence is fed to the marker pulse shaper which generates a double pulse for use as a time reference base in separating the various programs at the receiver. The operation of the marker shaper is similar in part to the operation of the time modulator, except for constant clipping bias and the addition of an open-circuited delay line. The delay line produces reflections which are combined with the original pulses to produce the double pulse characteristic used for

* Nine-thousand-cycle audio fidelity was chosen for reasons of convenience in this particular demonstration but does not in any way constitute a limitation of the system.

Another modulation technique utilizes the Cyclophon, a special tube developed by the Federal Telecommunication Laboratories. Based on the cathode-ray tube, it is enclosed in an evacuated envelope. Electrodes *A*, *B*, *C*, and *D* shown in Figure 7 are the gun and deflecting plates necessary to produce an electron beam. As the beam passes through deflecting plates *F*, it is caused to revolve by a sinusoidal potential which is applied directly to one pair of deflecting plates and at 90-degree phase displacement to the other pair. This causes the beam to rotate around the edge of the aperture plate *G*, passing for a small time interval through each of the 24 windows and falling on the corresponding dynode shoe *H*. The aperture width, beam width, and rotation are designed to give an interval of the desired duration. When the beam strikes the shoe secondary electrons are emitted from the shoe and collected on the aperture plate which is operated at a slightly higher potential than the dynode shoes.

As the beam scans the apertures in succession, a pulse of current flows through each load resistance *R*. Each pulse is related in time to the pulses in the other dynode circuits by the mechanical distribution of the window around the aperture plate. Each dynode load resistance is shunted by a capacitance *C* in order that the pulses may have a relatively slow but linear build-up time.

A series of pulses produced by the Cyclophon is applied to each channel modulator. These channel modulators are simple clippers which controlled

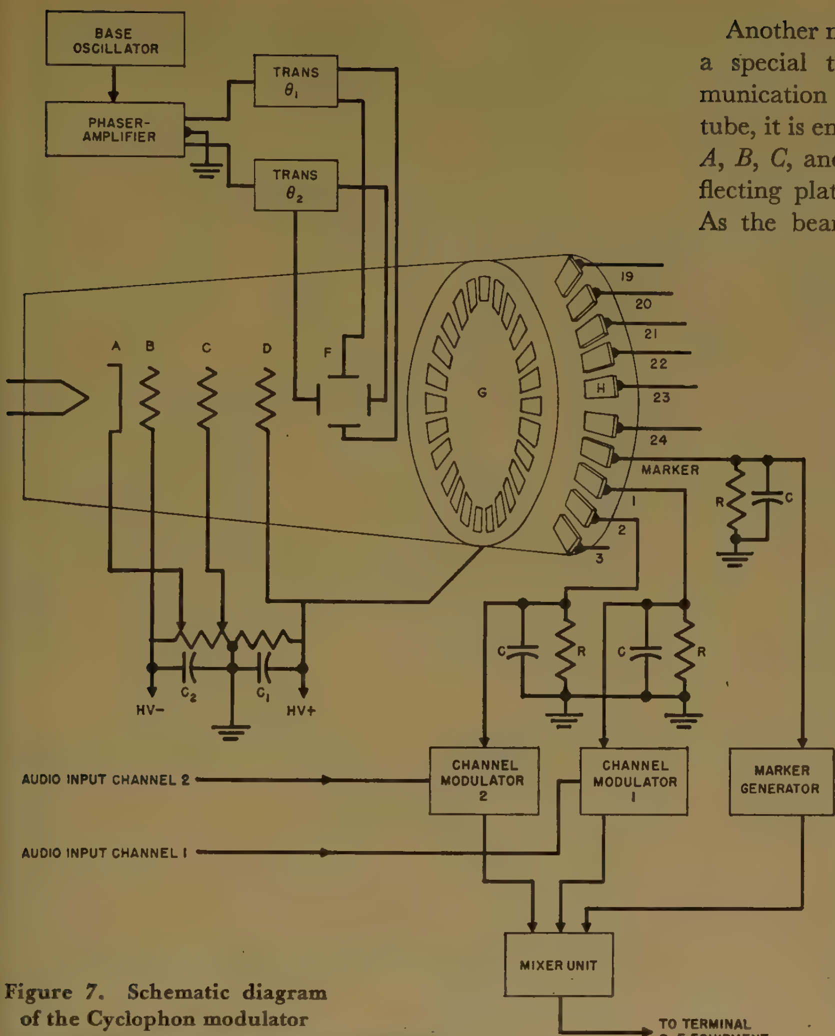

Figure 7. Schematic diagram of the Cyclophon modulator

subsequent marker pulse separation in the receiver.

After processing, the nine pulse sequences are interleaved and fed to the mixer shaper for further amplification and improvement of the pulse shape. The pulse output of the multiplex modulator, having an over-all repetition rate of 216 kilocycles, is then fed to the radio-frequency transmitter.

Figure 8. Transmitter antenna

Figure 9. Directional receiving antenna

by the modulating signal isolates a small slice of the Cyclophon pulse. The width of this slice depends upon the instantaneous amplitude of the audio-signal. These width-modulated pulses are differentiated and clipped as described previously.

Breakthrough between channels is prevented by including a volume compression unit in each channel modulator. The 24 apertures provide facilities for multiplexing 24 programs. However, to date only eight wide-band channels have been combined for broadcasting, although point-to-point transmission has been accomplished with all 24.

RF Transmitter. The radio-frequency transmitter consists of two sections, a modulator and an oscillator. The modulator is a wide band video amplifier of sufficient output to key the 930 megacycle oscillator. The oscillator proper is an air-cooled ultrahigh frequency triode type *A-2214-D*, which is tuned by a resonant coaxial line element. Single control tuning is provided within the operating range of 920 to 940 megacycles. Pretuning to this frequency range is accomplished by adjustable shorting sections in the resonant transmission line elements.

The oscillator has high inherent frequency stability so that further stabilization was not required in the demonstration equipment. The average power output, 40 watts maximum, corresponds to a peak pulse power of approximately 800 watts.

Transmitting Antenna. The transmitting antenna, shown in Figure 8, is a vertically stacked array of horizontally mounted loops. Its radiation pattern is concentrated in a horizontal direction with 360-degree coverage. The radiators forming the loops are metallically supported from the mast. Both supports and radiators form part of the coaxial feeding circuit. No balanced lines are used in the circuit, and no stubs are necessary to obtain a match to the 50-ohm solid-dielectric coaxial feeder.

Receiving Antenna. A directive antenna (Figure 9) is used. It consists of a double dipole at the focal point of a parabolic reflector, with a gain of 17 decibels in the receiving direction. The output is fed to the receiver by a 50-ohm solid dielectric coaxial transmission line.

Receiver. The receiver uses conventional tubes and components and consists of the functional equipment shown in Figure 10. The radio-frequency portion is of conventional superheterodyne design and consists of the local oscillator, mixer, and intermediate-frequency amplifier. A crystal is used in the first detector and a broad intermediate-frequency bandwidth is provided to pass the pulse frequencies. This also aids stability and minimizes regeneration.

The pulse or video detector is of conventional amplitude type and includes shaping and clipping of the pulses for further signal-to-noise improvement. The pulses then are passed on to a second or audio detector,

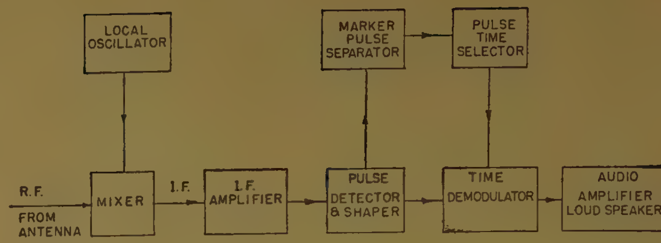

Figure 10. Block diagram of PTM multiplex receiver

which has a double function; time selection of the desired pulse channel, and its demodulation to give the audio program output. This is a simple and certain method of "tuning" with no possibility of misalignment since only push-button switching is involved.

The marker pulse is separated from the channel pulses by means of its double pulse characteristic and fed to the pulse time selector, which consists of a tapped delay line. The marker pulse separator is an open-circuited delay line identical to the one used in gen-

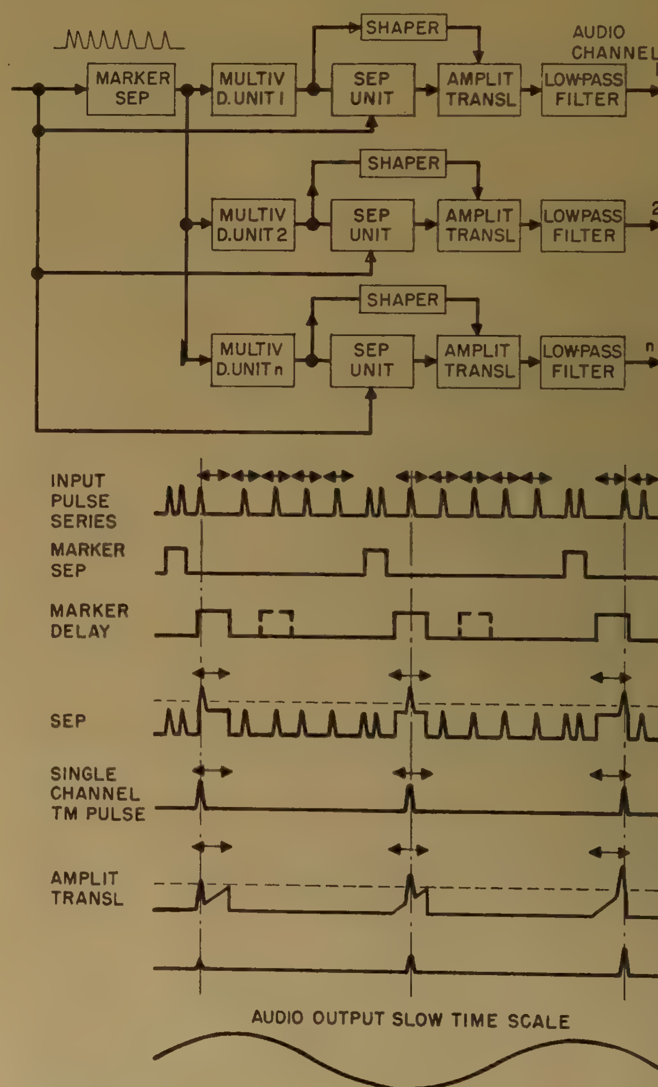

Figure 11. Multiplex demodulator, multivibrator type

erating the double pulse in the modulator. When the reflected and incident pulses are combined, components of the marker pulse in the direct and reflected series are superimposed and the resulting double amplitude pulse is removed by clipping.

The marker pulse then is delayed by an amount which depends upon the setting of the selector switch, so as to coincide in time with the desired channel pulse sequence. The delayed marker pulse generates a saw-tooth pedestal pulse having a width of four microseconds, which is more than adequate to overlap the plus or minus one microsecond modulation of the given channel pulses. When this saw-tooth pedestal pulse is combined with the pulses at the input of the time demodulator, the desired channel pulse series rides on the sloping portion of the pedestal at levels corresponding to their time positioning.

The time demodulator is biased to block all pulses which do not ride upon the pedestal. Since the resultant amplitude of the elevated pulses varies in accordance with their time positioning, the output of the demodulator consists of amplitude modulated pulses.

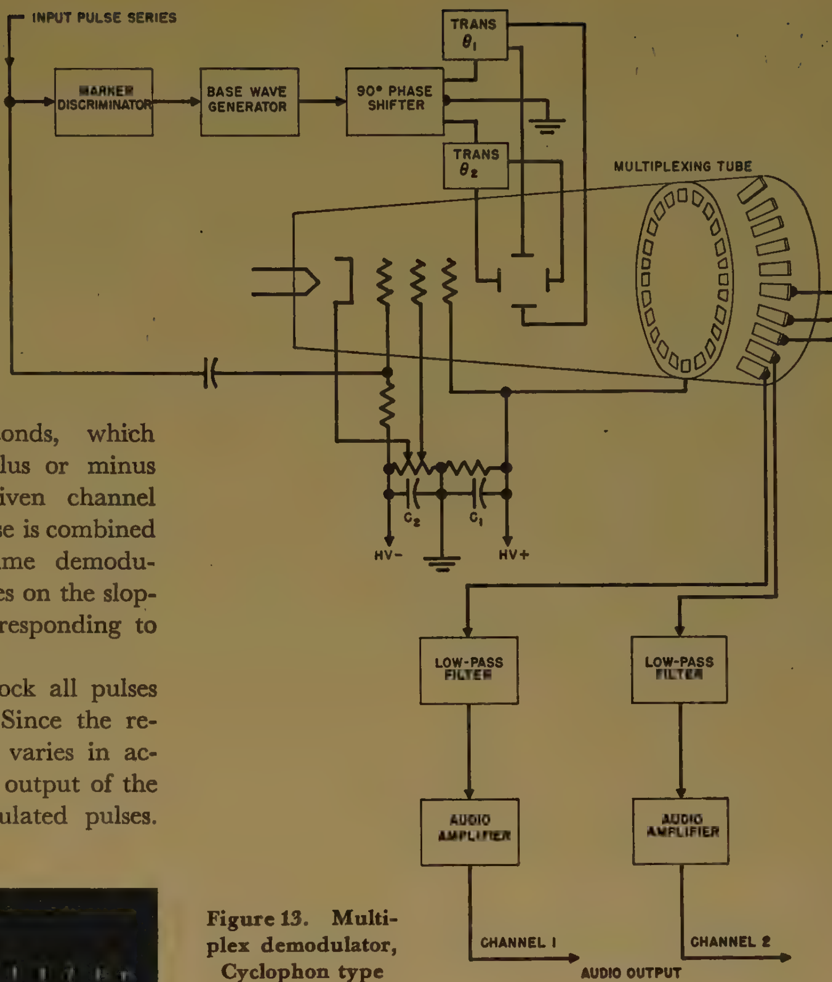

Figure 13. Multiplex demodulator, Cyclophon type

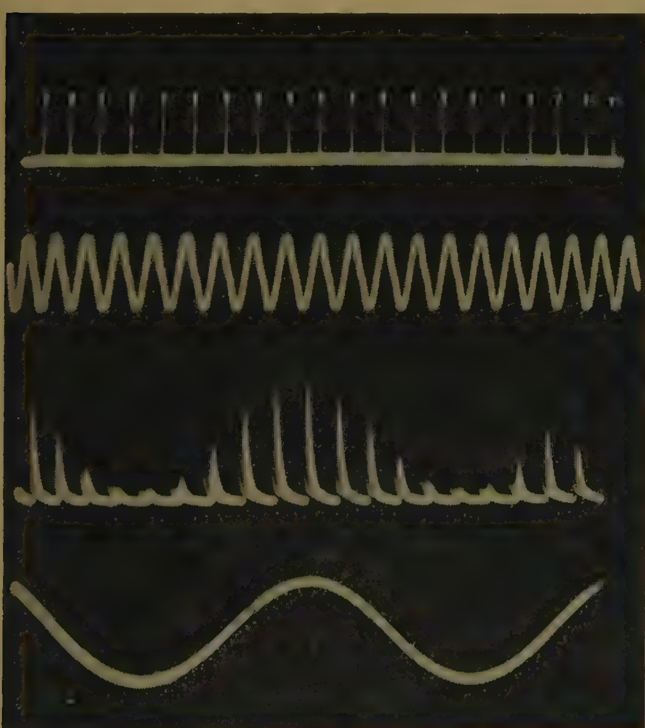

Figure 12. Oscillogram of demodulation sequences of Cyclophon demodulator

From top to bottom:

Single-channel time-modulated pulses
Sinusoidal base voltage
Output amplitude-modulated pulses
Output of the low-pass filter

A filter then removes the repetition frequency so that only the pulse envelope corresponding to the desired audio signal is fed to the audio output amplifier.

A multivibrator may be substituted for the delay network. A sloped pedestal pulse may be used to remove and amplitude translate the channel pulses simultaneously. (Figure 11.)

The Cyclophon has been adapted to demodulation and provides greater stability and simplicity. The receiver tube is similar in construction to the modulator tube except that the apertures differ in general dimensions. The first grid of the tube normally is biased to cut-off and the flow of the electron beam is controlled by channel pulses which are applied to the grid. The marker pulse is separated from the series by a delay line as described previously and applied to a tuned circuit to produce a sine wave of constant amplitude and frequency. The sine wave is applied to the two pairs of deflecting plates to rotate the beam. The aperture dimensions are determined by the time-modulation displacement, guard time, number of channels, and other characteristics of the modulation system.

The spatial relationship of the apertures with respect to the rotation of the beam serves to isolate the individual channels. The relation between aperture location and

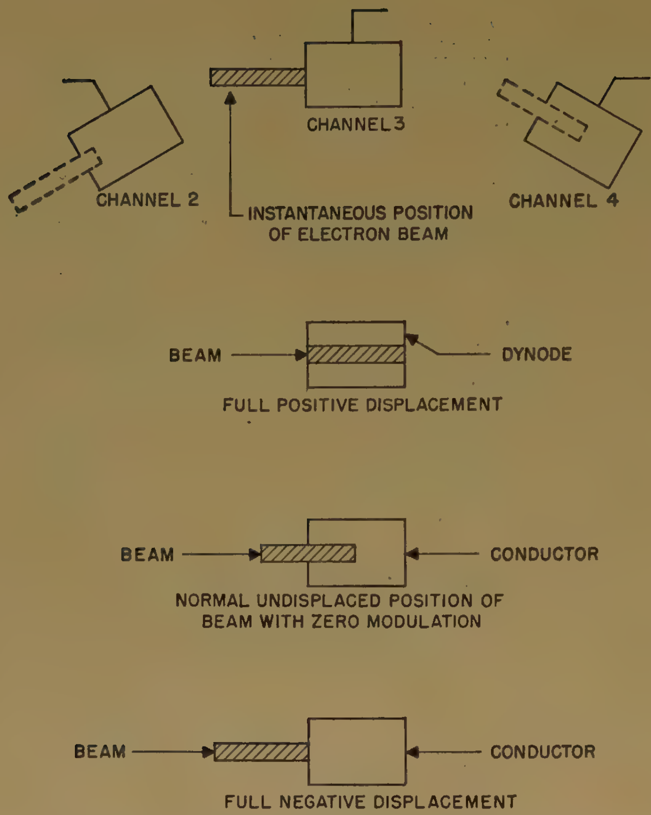

Figure 14. Cyclophon tube demodulation process

instantaneous time position of the beam produces the translation into amplitude modulated pulses as shown in Figure 12. The electrons passing through the aperture and striking the dynode cause secondary emission current in the form of amplitude modulated pulses. As described previously, a low pass filter is used to separate the audio signal.

An interesting feature of the receiver is that all programs may be received and fed simultaneously to separate audio output channels simply by providing additional demodulator sections, each of which is controlled by a properly timed marker pulse. One master receiver of this type is sufficient to feed a program distribution system within an entire apartment building, hospital, hotel, and so forth. Listeners in any room provided with service need have only a push-button controlled audio amplifier and loud-speaker in order to select any of the received programs independent of the choice made by other listeners.

CONCLUSION

Ultrahigh-frequency multiplex broadcasting, as discussed here, has opened up significant new possibilities in the field of very high frequency radio transmission. Of the many advantages offered through this system, those which warrant the most consideration are

1. Maximum use is made of the optimum transmitting location.
2. Duplication of transmitting and antenna systems is avoided.
3. The problem of reflections at the receiving end is simplified by the use of a fixed directional antenna. This use of a fixed antenna is made possible by the single common transmitting point.
4. The creation of an extensive network of repeaters connecting the several service areas is simplified considerably and made more economical.
5. A simplified method is provided for combining programs at the transmitter and separating them at the receiver without deleterious cross talk effects.
6. A fixed-tuned receiver may be used for all programs.
7. The problems of noise reduction and distortion are simplified considerably.

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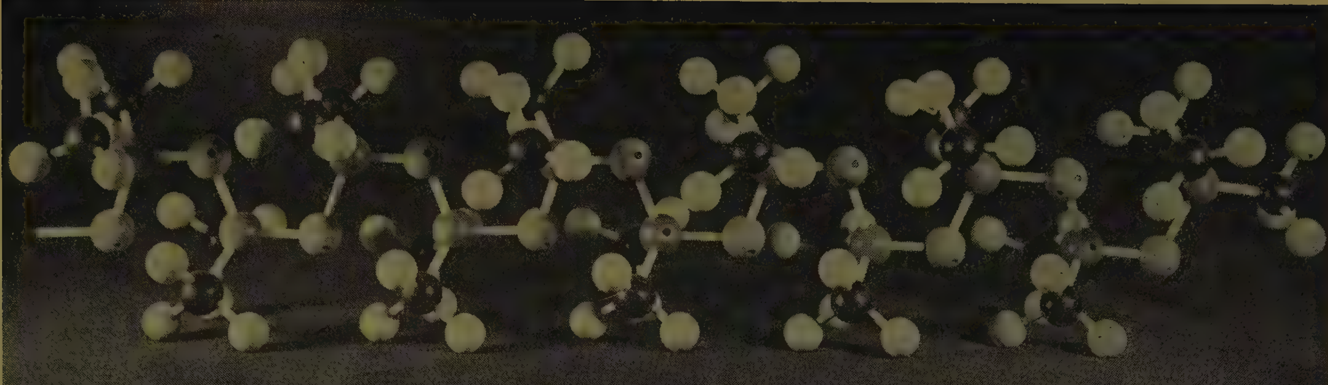
Electronic Crystal Clock

The only continuous time signal service is provided to the world by the National Bureau of Standards. One or more of the broadcast frequencies (5, 10, and 15 megacycles per second and 2.5 megacycles at night) is being used continuously. A crystal clock, utilizing electronic circuits instead of the conventional clock mechanisms, has been developed to insure accuracies to within a microsecond for use in navigation, seismology, and geological surveys. The flawless quartz crystal, the heart of the circuit, has a resonance frequency of approximately 100,000 or 200,000 cycles per second, and is sealed in a glass or metal enclosure to insure against variations in pressure and humidity.

The crystal oscillates continuously and the resulting stable frequency is divided with no loss of accuracy to 60 cycles per second. This 60-cycle frequency supplies power to a synchronous motor which, through gear trains, drives contacts that give intervals of 1 minute, 5 minutes, and 30 minutes to control the automatic announcement equipment of the transmitters. The motor also operates a 1-second contact which causes a very accurate seconds pulse to be broadcast.

The absolute accuracy of the frequency of the crystal oscillator is a few parts in 100 million. Although the seconds pulses are obtained by exact division of the quartz plate frequency, phase shifts and other difficulties decrease its accuracy to one part in one million.

The absolute time is supplied by the Naval Observatory. The broadcast signals constantly are compared with the absolute time and extrapolations of the data made to correct the broadcast signal. The equipment used to compare the various crystal clocks measures accurately a rate of change equivalent to one second in 50 years.



Silicones—a New Continent in the World of Chemistry

S. L. BASS

Silicones now are available in commercial quantities as fluids for use in hydraulic devices, as lubricating oils, as liquid dielectrics, in high vacuum diffusion pumps; silicone compounds for waterproof insulation in ignition systems and high-frequency communications equipment; greases for very high and very low temperature lubrication; "rubber" for heat-resistant gaskets, diaphragms, tubing, electrical insulation; various resins for insulation, protective coatings, bonding agents for inorganic laminations. This new "continent" in the world of industrial chemistry has extended enormously the known boundaries and opened many new areas for exploration.

WHEN Columbus started out, the coast of Europe was well known and the coast of China had been explored. He assumed, therefore, that by sailing west from Europe he would reach the coast of China. No one knew then that a great continent lay between Europe and Asia.

The same condition was, until quite recently, true in the chemical world. Men had known about inorganic materials such as ceramics, glass, and metals for centuries. They had known of organic materials based principally upon carbon and its compounds for generations and had developed thousands of synthetic organic materials in the more recent past. But no one knew that between these two fields lay a new chemical continent of semi-inorganic materials known today as silicones. Organic chemists started to explore the simple organo-silicon compounds some 50 years ago. It was not until the early 1930's, however, when chemists at the Corning Glass Works started to investigate the organo-silicon oxide high polymers that the importance of this new chemical continent began to appear.

Like glasses and the mineral silicates, of which fibrous glass, mica, and asbestos are familiar forms of heat-resistant insulating materials, the silicones also are derived from silica. Chemically, the silicones, like glass and the mineral silicates, are built upon a heat-stable skeletal structure of silicon atoms joined to each other through oxygen atoms. In the silicones, however, each silicon atom has attached to it one or more organic groups.

THE SILICONE MOLECULE

Sand is the source of silicones, just as it is of glass. However, instead of its being combined with inorganic oxides from lime and soda, it is altered rather radically by being put through a series of chemical processes. A grain of sand is, in effect, a complex molecule of silica. Each silicon atom is linked to four oxygen atoms which in turn link it with other silicon atoms. In making silicones, part of those oxygen atoms are replaced by organic hydrocarbon groups derived from coal or oil.

This is a complex process which is interesting primarily to chemists. The job of silicone chemists and, to no little extent, their art, is so to "tailor" the high-polymeric organo-silicon oxide molecules that a variety of products, each designed to meet specific use requirements, can be produced.

Already a large group of new engineering materials have been derived from sand. These materials are

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Figure 1. Silicone-insulated test motors are operated alternately at temperatures up to 310 degrees centigrade and exposed to 100 per cent relative humidity

Tests show that moisture is excluded after thousands of hours of thermal aging

available in a wide variety of physical forms. They include oils, compounds having a grease-like consistency, resins for heat-resistant enamels, laminates and molding plastics, and even a semi-inorganic rubber called "Silastic." In this age of chemical marvels, when people expect the chemist to pull new and ever more astounding marvels from under his hat, the production of rubber from sand is among the more astounding accomplishments of chemistry.

HEAT STABILITY

All these silicone products are characterized by a higher order of stability to heat and by greater resistance to moisture than conventional organic materials in the same physical forms. This heat stability and the suitability of silicone compounds for use in electrical insulation are inherent in their chemical structure. In the silicones, only two kinds of chemical bonds, the Si–O–Si and the C–Si bonds, are significant. The silicon–oxygen–silicon bonds are extremely stable to heat, as one would expect from the fact that these are the same bonds which exist in the mineral silicates. The carbon–silicon bonds also have a higher order of heat stability and greater resistance to oxidation than the carbon-to-carbon bonds which are basic in organic materials.

As a consequence of this greater heat stability, the silicone resins are natural complements to fibrous glass, mica, and asbestos insulating materials. The silicone resins provide the heat-resistant resinous dielectric necessary to bond these materials together. They also bond the insulating materials to the copper and steel used in building electric equipment. This bond is highly resistant to heat. It not only holds the insulation together, but also excludes moisture even after long exposure to high temperatures, as rigorous laboratory tests have shown. Thus, through the use of silicones together with inorganic insulating materials, a new type of electrical insulation has become available. This new class—silicone insulation—is almost immune to heat and moisture, the principal enemies which conspire to reduce the life of electric equipment.

WATER REPELLENT

In addition to heat stability, other useful properties are inherent in the silicone chemical structure. All silicones are water repellent, and the methyl silicones are particularly so. The methyl silicone oils are long-chain structures of silicon atoms carrying two methyl groups each. The silicon atoms are joined to each other through an oxygen atom, the hydrocarbon portion of the molecule acting like a paraffinic umbrella for the rest of the molecule. Applied to the surfaces of glass or ceramic insulators, the silicon–oxygen–silicon portion of the molecule attaches itself to the surface, leaving the hydrocarbon portion upward. When water or moisture condenses on this surface, it does not do so in a continuous film, as in the case of an untreated glass surface, but in distinct droplets. This silicone treatment of

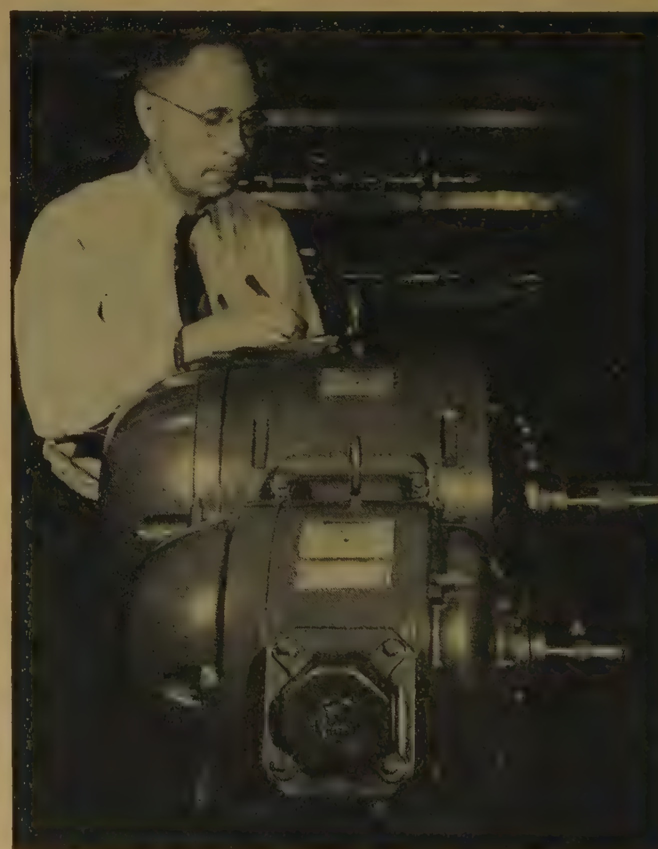

Figure 2. Both motors operate at the same speed and deliver ten horsepower

The silicone-insulated motor weighs about half as much as, and is half the size of, the larger motor

insulators in radio sets, for example, prevents leakages across the surface because no continuous film of moisture forms to conduct them.

The waterproof property of silicones was utilized in a translucent and nonmeltable silicone paste, which proved to be quite essential to the proper operation of aircraft ignition systems and disconnectable joints in radar systems during the war. It served as an auxiliary dielectric and waterproofing seal for the ignition cable insulation where it entered the spark plug wells and magneto plugs of military aircraft. It prevented condensation of moisture at these points and kept the ignition system from being short-circuited. Another water repellent application of silicone oils was initiated during the war and is still being developed—the production of a water repellent filler made of fine glass fibers for use in life jackets and as thermal insulation.

STABLE VISCOSITY

One of the fundamental properties of long-chain silicone molecules is their resistance to associating with each other in ordered arrangement at low temperatures. These silicone fluids are characterized by an exceptionally flat viscosity–temperature slope. They do not thin out at elevated temperatures or thicken at low temperatures to so great an extent as do the petroleum fluids. Another manifestation of this property is found in the flexibility and resilience of silicone "rubber" at low temperatures. As a matter of fact, this silicone product retains its flexibility at temperatures only slightly above that of "dry ice." Because of its heat resistance it is useful at temperatures up to 200 degrees centigrade. It is, therefore, useful over a wider range of temperature than any other material having rubber-like properties.

Another useful property inherent in the fact that silicones are high polymer molecules is their incompatibility with other plastic materials. A silicone fluid applied as a very dilute water emulsion spreads over the metal surface of dies to form an extremely thin film to which hot plastics and synthetic rubbers do not adhere. This property is of great value in the manufacture of tires and other molded-rubber articles. It is also useful in the molding of other plastic materials.

Silicone Chemistry, In Brief

(*Westinghouse Engineer*, September 1945)

The first step in the manufacture of silicones is the conversion of sand (silicon dioxide) to silicon tetrachloride ($SiCl_4$) through the use of chlorine obtained by the electrolysis of brine. From coal and petroleum are derived several hydrocarbons, such as benzene, methane, and ethane. These are converted to chlorohydrocarbons by reaction with chlorine. One or more of these chlorinated hydrocarbons are reacted with magnesium to form a Grignard reagent which then is combined with the silicon tetrachloride. The product is magnesium chloride (akin to the original brine) and a mixture of organo-silicon chlorides. These organo-silicon chlorides have some hydrocarbon bound directly to the silicon atom in place of one or more of the chlorine atoms originally attached to silicon to form silicon tetrachloride. The hydrocarbon unit may be any one of many possible ones, depending on the nature of the product sought. It may be CH_3 or C_2H_5, for example. In any case it is thought of as a unit and is termed the hydrocarbon radical, or simply *R*. When treated with water, the organo-silicon chlorides react to form hydrochloric acid and organo-silicon oxide condensation products known to chemists as polysiloxanes. These large molecules built upon a silicon-oxygen linkage are the units used in the molecular architecture of the silicones.

These large silicone molecular structures have approximate analogues among the hydrocarbons. But there is an important and essential difference. In the hydrocarbons each carbon atom is linked to an adjoining carbon atom, thus:

$$
\begin{array}{ccccccc}
 & H & & H & & H & \\
 & | & & | & & | & \\
— & C & — & C & — & C & = \\
 & | & & | & & | & \\
 & H & & H & & H &
\end{array}
$$

In the silicones, however, each silicon atom is linked to an adjoining oxygen atom in this fashion:

$$
\begin{array}{ccccccc}
 & R & & R & & R & \\
 & | & & | & & | & \\
— & Si & —O— & Si & —O— & Si & — \\
 & | & & | & & | & \\
 & R & & R & & R &
\end{array}
$$

It is this silicon-to-oxygen bond that gives the silicones some of their most valuable properties.

The hydrocarbon radical is the only organic component and is bonded directly to the silicon atoms. The resulting silicone is, then, clearly neither organic nor wholly inorganic. It lies midway between the two conventional fields of chemistry and may be termed a semi-inorganic compound. There are many possible hydrocarbon radicals, but CH_3 (methyl), C_2H_5 (ethyl), and C_6H_5 (phenyl) are the more common ones. Choice of a given hydrocarbon unit from among many is one of the several variables available to the silicone molecular engineer.

Another variable in the design of a silicone is the length of the chain. This chain may be only a few silicon–oxygen–silicon links long, or thousands of these organo-silicon oxide units may be linked together. Eventually, each molecule must be terminated by a blocking unit, which can be an *R* unit in place of an oxygen atom. The chemist can allow the molecule to grow to almost any desired length, and stop further growth by adding a blocking unit, thus:

$$
\begin{array}{ccccccccc}
 & CH_3 & & CH_3 & & CH_3 & & CH_3 & \\
 & | & & | & & | & & | & \\
CH_3— & Si & —O— & Si & —O— & Si & —O— & Si & —CH_3 \\
 & | & & | & & | & & | & \\
 & CH_3 & & CH_3 & & CH_3 & & CH_3 &
\end{array}
$$

Thus we have a straight-chain molecule. However, one chain can be linked to the adjoining molecule by cross links to form a three-dimensional structure. This is still another variable useful to the architect of silicone molecules.

Figure 3

Class B insulated motor failed after 3,760 hours at 200 degrees centigrade

Silicone-insulated motor failed after 5,178 hours at 300 degrees centigrade

Both windings look about alike and show about the same degree of deterioration. The class B motor caught fire on failure, while the silicone insulated motor failed because of oxidation of the copper

In the silicone fluids, various combinations of properties often lead to unexpected uses. For example, their incompatibility together with their surface effects at the interfaces of oil–air systems has been utilized to prevent the foaming of crankcase oils. Traces of silicone oil in petroleum oil are sufficient to prevent foaming.

Similarly, in aqueous systems foaming is often a serious and costly problem. A new silicone compound has recently been developed to prevent the foaming of aqueous systems or to kill foams once they have been formed. This product is effective at very high dilutions, varying from one to one hundred parts per million.

In England the natural compressibility of certain silicone fluids has been utilized in a "liquid spring" hydraulic shock absorber that has been developed for use in aircraft landing gear. As the compressibility of the silicone fluids is 15 to 25 per cent greater than petroleum fluids, the makers believe that the landing of heavier aircraft on present fields may be possible without increasing the size or weight of the landing gear.

The flat viscosity–temperature slope of silicone fluids together with their high flash point has led to an extensive study of their use as hydraulic fluids in aircraft by the Naval Research Laboratory, Washington, D. C.

This same flat viscosity–temperature slope of silicone fluids together with their shear resistance has led to the development of a torsional vibration damper for automotive crankshafts. In this device a free-wheeling fly wheel floats in a film of silicone oil which damps any torsional vibration in the crankshaft.

In these applications some well-known engineering principles have been made practical for the first time. Correct in theory, these principles were not practicable until silicones were developed and proved to have the properties necessary to reduce theory to practice.

ECONOMY

There are very few established uses for silicone products which do not result in a considerable saving

Figure 4. The effectiveness of a silicone defoamer in killing foam in a rosin soap solution

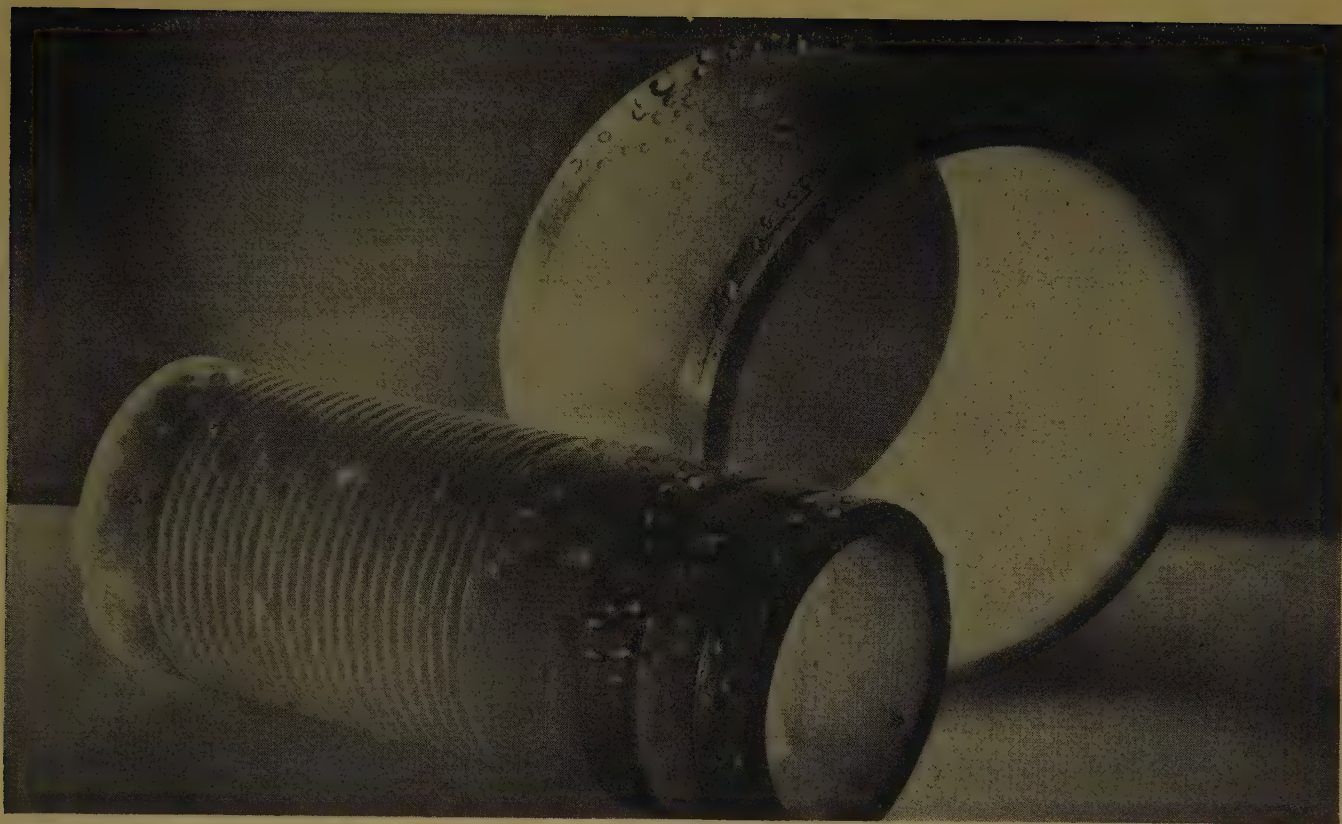

Figure 5. The water repellent nature of the silicones

of time and money. An example is the speeding up of production and the reduction of rejects through the use of a silicone mold release in rubber molding. Silicone resins may be used in formulating a more practical enamel for sheet steel used in domestic stoves. Another example is the saving of materials and the reduction of repair time in electric equipment which result from the use of silicone electrical insulating materials.

It is probable that the price history of most important new engineering materials will be repeated in the silicones. As volume increases, production costs should decrease, opening new fields of usefulness and larger volume markets.

FUTURE OF SILICONES

In this age of extremely high and low temperature operation, the unusual properties of silicone materials probably will become increasingly important. The last $2^1/_2$ years already have demonstrated this with respect to the use of silicone-insulation for electric apparatus. Actual tests of silicone insulated electric equipment under severe and accelerated conditions of heat and moisture have shown that such equipment is capable of operating hundreds of times longer than conventional insulating materials. Manufacturers of motors, transformers, contactor coils, and other electric equipment are beginning already to standardize on silicone insulation in their lines. Maintenance and repair shops are rewinding an increasing number of motors with silicone insulation.

The silicone continent, nevertheless, is just beginning to be explored, and many years will be required to disclose the full extent of it.

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Employer Practice Regarding Engineering Graduates

This report presents and analyzes the results of a preliminary survey of employer practice regarding engineering graduates which was undertaken by a subcommittee of the Engineers Joint Council in conjunction with a series of studies and surveys being carried on by the EJC and its constituent societies pertaining to the economic status of the engineer.

THE YOUNGER ENGINEERS actively have been seeking advice and guidance from the national engineering societies, of which they are junior members. The Engineers' Council for Professional Development has endeavored consistently to better the professional status of the engineer, but in the recent years there has been an insistent request from a small but voluble portion of the junior engineers to obtain from the societies some tangible aid regarding their economic status.

The Engineers Joint Council recognized that surveys of the engineering profession regarding salaries and advancement based upon data obtained from employees as individuals should be supplemented with a survey of employers in industry. The object of this survey is to learn directly from a representative group of industrial employers their attitudes and policies pertaining to the selection, training, placement, advancement, guidance, and professional activities of engineering graduate employees.

Before canvassing industry on a large scale, a trial questionnaire was sent in May 1946 to 174 employers of engineers, including small and large organizations. Replies were received from 104 employers in 19 fields of industry up to August 1 and form the basis of this report. Colleges also were included, as they, too, employ the graduates of their own or other schools, as well as those who return from industry to teach.

The data from the questionnaire have been studied with a view toward preparing a more complete questionnaire to be sent during the fall of 1947 to a larger and more representative list of employers.

This report has been prepared in the belief that the present data may be helpful to the junior engineers, the employers of engineering graduates, the colleges from which future graduates will be available for employment, and the engineering societies.

Collectively the 104 co-operators employ more than 2,000,000 persons, of whom about 40,000 are engineers. Because of the representative character and distribution of the co-operators, the data received from this preliminary survey are regarded as worthy of a brief analysis and report. (See summary data in Table I).

GENERAL OBSERVATIONS

The following general observations are based upon the questionnaires returned.

Who Are Hired? Ninety-six per cent of the co-operators employ cadet engineers directly upon graduation from engineering schools, but only 4 per cent recruit their engineering staffs exclusively from the new graduates. About 43 per cent hire more than half of their new engineer employees after one or more years' experience with other employers. This is evidently a matter of necessity or expediency rather than preference, because more than 60 per cent of those reporting indicate that they prefer to hire the new graduate.

How Are Cadet Engineers Recruited? Seventy per cent of those replying send representatives to engineering schools, who interview students individually; nearly all of these discuss the candidates personally with members of the college faculties, in addition to interviewing the students themselves. The conditions existing in the employment field prior to and to some extent at the time of this survey are evidenced by the fact that 51 per cent of the co-operators invite students to visit their plants at company expense.

Other means of recruiting new graduates are apparently of little avail. The other methods reported, in descending order of effectiveness, are voluntary applications, advertising, summer employment of students, employment agencies, and recommendation of friends.

How Are Experienced Engineers for Specific Openings Obtained? For filling specific openings, advertising is used by 50 per cent of those replying and employment agencies by 35 per cent. Thirty-five per cent also utilize

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Full text of a report issued by the Engineers Joint Council. This report was prepared by a subcommittee of the EJC Committee on the Economic Status of the Engineer, and presents the results of the returns received from a preliminary questionnaire survey conducted between May and August, 1946. The Subcommittee on the Survey of Employer Practice Regarding Engineering Graduates is composed of the following society representatives:

E. G. Bailey (ASME), *chairman*
American Society of Civil Engineers, William N. Carey
American Institute of Mining and Metallurgical Engineers, Francis B. Foley
American Society of Mechanical Engineers, H. T. Woolson
American Institute of Electrical Engineers, R. C. Muir
American Institute of Chemical Engineers, Lawrence W. Bass
National Society of Professional Engineers, William F. Ryan

There are two other subcommittees of the EJC Committee on the Economic Status of the Engineer, one now compiling a report of a recent survey of the engineering profession, and the other preparing a manual on collective bargaining by engineers in professional work.

the facilities of Engineering Societies Personnel Service, Inc.,* 18 per cent consult placement bureaus, and 12 per cent report that their present employees bring men in. A few co-operators obtain engineers from associated companies, but United States Employment Service and the National Roster of Scientific Personnel each are used by only one company in this group.

How Are Engineering Employees Selected? Twenty-five per cent of those reporting do not differentiate between engineers and other employees in the process of hiring. The other 75 per cent rely chiefly on personal interviews between the candidates and engineering executives, although 20 per cent of the co-operators employ aptitude or other tests for evaluating the applicant's ability. Only two companies report that engineers are hired without meeting at least one executive engineer.

Of those who rely on interviews with engineering executives, 35 per cent depend on the judgment of a single executive, and less than 50 per cent indicate that the candidate is interviewed by an engineer as high in rank as division head or assistant chief engineer. On the other hand, several companies report that each candidate is interviewed by several responsible engineers, including the top ranking engineering executive.

What Are the Bases on Which Engineering Employees Are Selected? The questionnaire listed nine items presumably considered when selecting an engineering employee, asking each co-operator to list the order of importance given to each in arriving at an over-all evaluation. From a statistical analysis of the replies, weighting the first, second, and lower choices in the way that preferential ballots usually are counted, the considerations which carry the most weight in selecting a candidate for an engineering position, in the order of their importance are as follows:

1. Personality.

2 and 3. { Scholastic record. / Indicated promise of development in specific field of engineering. }

4. Engineering experience.
5. Evidence of ability to co-operate with others.
6. Recommendations by qualified persons.
7. Indicated promise for executive development.
8. Standing of college from which candidate was graduated.
9. Salary requested.

If only first choices are considered, the order of preference is changed somewhat, engineering experience ranking second instead of fourth, but personality still leads the list. Experience no doubt would rank higher and scholastic record lower, if it were not for the fact that the employment of recent graduates is uppermost in the minds of those seeking to increase their engineering forces.

Perhaps the items given in the questionnaire were not the best that might have been chosen to portray to the young engineer the qualifications most sought after by the employer. In the blank space in the questionnaire ten co-operators added "interest in assignment"; two added "interviewer's evaluation"; and three, "character."

As some of these items are the same or similar attributes in other words, the desirable traits well might be summarized as a well rounded out individuality with a good personality, qualified by education and experience to make a good engineer.

Is the Present College Training of Engineers Satisfactory? Eighty-three per cent voted yes, 14 per cent no. The predominant criticism of applicants for engineering employment by the 14 per cent were:

1. Lack of fundamentals; physical sciences and mathematics.
2. Inarticulateness in speech and writing.

3, 4, and 5. { Lack of education in the humanities. / Lack of drafting and design experience. / Lack of knowledge of economics and business. }

6. Lack of knowledge of operation and production.

The Compton Committee of the SPEE* quotes from another survey of 100 companies by the American Telephone and Telegraph Company a similar question, the returns from which were as follows:

WHAT IS YOUR OPINION OF THE ENGINEERING GRADUATES?

Replies	Per Cent
Excellent or very good	12
Satisfactory	38
Deficient in certain particulars	35
No opinion	15
Deficiencies reported can be grouped as follows:	
Human relations	9
Use of English	9
Accelerated course graduates below par	7
Lack practical perspective	5
Lack training in business	2
Lack ability in design	2
Training too theoretical, needs broadening	2

What Is the Prevailing Policy in Regard to Starting Salaries and Advancement? Twenty per cent of the co-operators indicated that every new engineer employee is regarded as a special case, and starting salary is based on his particular qualifications. The others were divided about equally between those who are influenced by prevailing rates in other companies and those who indicated

* A separate corporation owned and operated by the four founder societies as a special employment service in the engineering profession, and supported by receipts from charges made to engineers who are placed in positions. The four secretaries of the founder societies constitute the board of directors of the organization, and the founder societies publications carry monthly summaries of men and positions available, information which also is circulated to many local sections and other interested engineering groups. The Engineering Societies Personnel Service at present maintains offices at 8 West 40th Street, New York, N. Y.; 211 West Wacker Drive, Chicago, Ill.; 100 Farnsworth Avenue, Detroit, Mich.; and 57 Post Street, San Francisco, Calif.

* The Outlook in the Demands for and Supply of Engineering Graduates. *Journal of Engineering Education*, American Society for Engineering Education (formerly Society for Promotion of Engineering Education), Lancaster, Pa., volume 31, number 7, September 1946.

that their salary scales are arrived at independently.

No company reports a starting monthly salary of less than $150, and only four less than $175. Five companies report starting salaries of more than $250. The median (50 per cent level) is approximately $207 per month.

The Compton Committee summarized data contributed by 125 companies in April 1946. The average starting monthly salary of graduates with bachelor degrees is $210, with variations from $125 to $320.

In regard to advancement after initial employment, only 26 of the co-operators gave data. They were all within 12 industries, but none had enough data to indicate a reliably consistent trend for the individual industry, therefore they were grouped and the average rate of advancement derived approximately as follows:

Time of Advancement	Minimum Percentage	Median Percentage Base = $207	Median Actual	Maximum Percentage
At the end of 6 months	2.5	8.0	$16.60	14.3
At the end of 12 months	3.6	14.6	30.30	28.6
At the end of 18 months	7.5	24.2	50.00	42.9
At the end of 24 months	10.0	29.2	60.40	57.2

In lieu of or in addition to standard increases, 76 per cent of the co-operators report that periodic reviews are made to determine salary increases on a merit basis, and 24 per cent are guided chiefly by recommendation of superiors. Less than 7 per cent indicate that adjustments are made to meet competition and retain capable men.

The Compton Committee report also shows starting salaries for holders of bachelors' degrees in 1939, and for masters' and doctors' degrees in 1939 and 1946.

The report of the EJC subcommittee on survey of the engineering profession, based upon questionnaires addressed to about 100,000 engineers, should be available in the near future, and will give more comprehensive data on salaries and actual rates of increase.

What Is Done for Technical and Professional Development of Engineer Employees? Only 50 per cent of the co-operators report that special provision is made for professional development of the young engineers in their employ, but practically all indicate that their engineering organization provides definite opportunities for professional advancement.

Thirty-seven per cent have formal training programs for young engineers; 65 per cent indicate that jobs are varied to provide a broad training; 41 per cent provide technical programs within the company; and 78 per cent encourage taking courses outside of company hours, of whom more than half contribute to the cost of tuition for such courses. (Some multiple choices are included in the foregoing percentages.)

Is Membership in Engineering Societies Encouraged? Practically all encourage membership in engineering societies. Nearly 30 per cent pay the dues of certain employees in certain societies. Traveling expenses usually are paid by employers for attendance at meetings when employees are authorized to serve on committees, prepare papers, present discussion, and the like.

SUMMARY OF SIGNIFICANT DATA

The previous statements gleaned from the returned questionnaires broadly cover the entire group of industries, without any differentiation between them. The significance and value resulting from them may apply generally to all employers of engineering graduates.

It is recognized that all industries are not equally interested and dependent upon the engineering graduate, nor are all industries equally attractive with recognized opportunities to the engineer. It is hoped that a more complete survey at some time in the near future will enable some real benefit to be derived for all concerned from a thorough analysis of individual industries. It is believed that some good along this line may be derived from this survey by grouping the industries in some manner relating to their interest in the engineering graduate. The percentage of engineers to total employees has been chosen as the basis for dividing the co-operators into four groups, *A*, *B*, *C*, and *D*, as shown in the Table I.

Item 8 gives the key to the grouping. The colleges, with a high percentage of about 45 per cent engineering graduates, constitute group *A*.

Group *B* includes the instrument industry with 6.6 per cent, electrical with 5.1, petroleum with 4.9, chemical with 4.2, and aircraft with 3.9 per cent.

Group *C* includes machinery with 2.0, building with 2.0, paper with 1.8, glass with 1.5, utilities with 1.4, metals with 1.4, and coal and coke with 1.0 per cent.

Group *D* includes textiles with 0.9, soap with 0.8, rubber with 0.7, automotive with 0.6, shipbuilding with 0.6, transportation with 0.5, and food with 0.3 per cent.

Perhaps of some significance is the interest displayed in the return of the questionnaire itself. Item 3 shows the percentage of returns from the groups to be: *A*—80 per cent, *B*—68 per cent, *C*—60 per cent, and *D*—47 per cent, with an average of 60 per cent.

There seems to be no significant relation between starting monthly salaries in the different groups in item 9.

ENGINEER AS EXECUTIVE

The results of two questions are given in the table as items 10 and 11, and are of equal interest to management and the young engineer. About 42 per cent of the executives and 37 per cent of the officers are engineering graduates.

ACCOMPLISHMENTS OF AND OPPORTUNITIES FOR ENGINEERS

Item 12 indicates that in the opinion of the co-operators the engineer's role in the development of the company

has been "very important." Group A estimates this importance at 100 per cent; B, 90 per cent; C, 77 per cent; and D, 65 per cent, with an average of 80 per cent. When it comes to the potential opportunities of the engineering graduate as compared with other employees with comparable educational or other preparatory background, item 13, he seems to meet with considerable competition all along the line.

As to the future, the engineering graduate is considered to have better opportunities for advancement by more than half of the co-operators in groups A, B, and C, and only 42 per cent of those in Group D (item 14).

NEED FOR ENGINEERS DURING THE NEXT FOUR YEARS

Item 15 of the table shows that over the next four years an average annual increase of about 8 per cent in the number of engineers was anticipated by the co-operators when they replied in June and July 1946, to that part of the questionnaire reading "Estimated number of engineers that will be employed in the near future, say 1950." The four groups agree fairly well, with A, 23 per cent; B, 32 per cent; C, 34 per cent; and D, 26 per cent. Weighted average of all co-operators is 31 per cent of the present engineer employees.

The Compton Committee report arrived at an estimate of 17 per cent per year. That survey was received in April 1946 from 125 companies in industry, employing 25,556 engineers, as against this survey covering 104 companies in June and July 1946, with 33,758 engineers among those reporting both engineer and total employees.

CONCLUSIONS

It is recognized by the committee that the data are of limited scope, and therefore should be accepted with some reservations.

The forthcoming report of the EJC Committee on Survey of the Engineering Profession should be awaited with much interest by all who have responsibilities relating to the engineering graduate.

This committee recommends to the EJC that a better and more complete questionnaire be prepared and a more extensive survey be made along the line in which this trial survey was directed, in the near future, perhaps in the fall of 1947.

The committee will be pleased to receive suggestions and co-operation toward the preparation of such a complete survey from anyone. Copies of the preliminary questionnaire sent out in May 1946, the replies to which form the basis of this report, will be sent to those requesting same from the committee. Inquiries and requests should be addressed directly to the Secretary, Engineers Joint Council, 25–33 West 39th Street, New York 18, N. Y.

Table I. Summary of Significant Data from Survey of Employer Practice Regarding Engineering Graduates

Industries Arranged in Groups According to Percentage of Engineers to Total Employees, Item 8

Item	A Colleges	B Instrument Electrical Petroleum Chemical Aircraft	C Machinery Building Paper Glass Utilities Metal Coal	D Textiles Soap Rubber Automotive Transportation Shipbuilding Food	Total and Averages Weighted by Individual Co-operators
1. Questionnaries sent out	10	47	74	43	174
2. Questionnaires returned	8	32	44	20	104
3. Questionnaires returned, per cent	80	68	60	47	60
4. Total employees	4,785	438,874	788,408	780,994	2,013,061
5. Total employees of those reporting, both total and engineering graduate employees	1,310	438,874	630,658	500,994	1,571,836
6. Engineering graduate employees	585	21,252	9,333	2,588	33,758
7. Engineer employees to total, per cent	44.6	4.85	1.48	0.52	2.15
8. Range in per cent of engineers to total employees, when grouped by industries	44.6	6.6 to 3.9	2.0 to 1.0	0.9 to 0.3	44.6 to 0.3
9. Starting monthly average salary, dollars	198	208	210	204	207
10. Executives who are engineering graduates, per cent of total executives	70	41	48	23	42
11. Officers who are engineering graduates, per cent to total officers	52	39	41	24	37
12. Engineers role in development of company "Very Important," per cent co-operators	100	90	77	65	80
13. Engineering graduate "Better Potential Opportunities" than other employees with comparable education, per cent co-operators	50	57	66	45	58
14. Opportunities for future advancement of engineering graduates "Greater than Ever", per cent co-operators	86	57	64	42	59
15. Estimated increase in engineering graduates needed in next four years, per cent of present engineers	23	32	34	26	31

A Policy for Electrical Engineers

—*A Message From the President*

As one of his first steps in acquainting the AIEE membership with the current status of AIEE action on the board of directors' resolution endorsing amendment of the National Labor Relation Acts insofar as it affects engineers, and as a means of coalescing membership opinion, AIEE President J. E. Housley addressed the following letter to all Institute officers on February 7.

Gentlemen:

There is a common bond among all engineers, scientists, chemists, and similar professional men. This bond is the basis of a policy which I submit to you:

The members of the American Institute of Electrical Engineers seek a restoration of their fundamental American liberties in the practice of their profession.

I am giving you the sense of the thinking of a majority of the officers and members I have met. The inspiration for this message to you was given by the following resolution adopted by the board of directors, at a meeting January 30, 1947:

RESOLVED that the president is hereby empowered, in his discretion, to proceed in efforts to bring about a revision of the National Labor Relations Act which will secure for engineers freedom of choice in the matter of collective bargaining.

Additional encouragement to you is afforded by the earlier action taken by a group of the Boston Section members. The following letter was presented to the board of directors on January 30, 1947:

At a meeting of the executive committee and the advisory board of the Boston Section of the American Institute of Electrical Engineers with the officers of the North Eastern District, the national president and other fellows of the American Institute of Electrical Engineers in the Boston Section on January 24, 1947, the following resolution was adopted unanimously: "Whereas the services rendered by an engineer are fundamentally individual in character, based on personal professional knowledge and skill in science and on judgment, initiative, and high integrity in the application to useful ends; be it resolved that the American Institute of Electrical Engineers, through its president and otherwise, exert all efforts to secure amendment of the Wagner Act to exclude all engineers, as well as all other persons in scientific work at the professional level, including such persons in training, from the provisions of the act requiring collective bargaining with employers."

That we cannot rest our faith wholly on legal machinery to protect the standing of engineers and to secure recognition of an engineering degree is strikingly implied by the following quotation from a speech made in 1944 by Judge Learned Hand:

Liberty lies in the hearts of men and women; when it dies there, no constitution, or law, no court can save it; no constitution, no law, or court even can do much to help it. While it lies there, it needs no constitution, no law, no court to save it.

Clark W. Ransom (A '36) has been appointed to represent AIEE on a panel composed of representatives from Engineers Joint Council constituents. He will serve in addition as my representative in Washington, D. C., on occasions. He will appear before a Congressional committee early in March when testimony of professional employees will be heard. I have offered unqualified support in working out legislative problems, to other Founder Societies, Engineers Joint Council, and the National Society of Professional Engineers.

News regarding the action of the AIEE board is expected to be reported in the technical press for the information of the engineering world. I will ask as a favor from the chairman and counselor receiving this letter that he please present it at the next meeting of the officers of his group and advise me of the sense of the thought of the majority present, toward the policy stated herein, and toward the adoption of confirming resolutions similar to that adopted by the Boston Section. At your discretion, you may present the information contained herein to the Section or Branch.

Future AIEE Meetings

North Eastern District Meeting
Worcester, Mass., April 23–25, 1947

Summer General Meeting
Montreal, Quebec, Canada, June 9–13, 1947

Pacific General Meeting
San Diego, Calif., August 26–29, 1947

Middle Eastern District Meeting
Dayton, Ohio, September 23–25, 1947

Midwest General Meeting
Chicago, Ill., November 3–7, 1947

Winter General Meeting
Pittsburgh, Pa., January 26–30, 1948

North Eastern District Meeting To Feature "Applications Engineering"

The Worcester Section will be host to a 3-day meeting of the North Eastern District and a Student Branch conference, April 23–25, 1947. Meeting headquarters will be the Hotel Sheraton, located on the common, in the heart of the city. A full program of technical sessions, built around the dominant theme, "applications engineering," combined with an interesting program for women, social events, a lively general session, and several excellent inspection trips all point to a very worthwhile meeting.

TECHNICAL SESSIONS

Eight technical sessions plus a student session well filled with papers will serve to build up the general theme of the meeting. Worcester, with its exceptional diversity in industry, seems an excellent setting for papers around the theme of "applications engineering."

INSPECTION TRIPS

Friday afternoon will be devoted to inspection trips to local industries and power systems. Among the places to be visited are the cable works of the American Steel and Wire Company, the central dispatcher's office of the New England Power Company, the Norton Company, and the Heald Machine Company. Additional special trips will be arranged for students.

LADIES' PROGRAM

Outstanding features of the ladies' program will include a trip on Wednesday afternoon to Longfellow's Wayside Inn in Sudbury followed by entertainment and dinner at the inn. On the Thursday program are trips to the noted John W. Higgins Museum of Armor and to Worcester's Fine Art Museum, followed by entertainment and tea.

(continued on page 392)

North Eastern District Meeting Worcester, Mass., April 23–25, 1947

Wednesday, April 23

8:30 a.m. Registration

9:30 a.m. Measurements and Electronics

DP.* A Self-Balancing Capacitance Bridge. **A. H. Foley**, General Electric Company

DP.* A Photoelectric Color-Temperature and Exposure Meter. **Thomas M. McCaw**, Worcester Polytechnic Institute

DP.* A New Type of Electronic Frequency Meter. **H. J. Reich, R. L. Ungvary**, Yale University

47-108. The Measurement of Acceleration With a Vacuum Tube. **Walter Ramberg**, National Bureau of Standards

9:30 a.m. Transformers and Capacitor Applications

47-107. Transient Characteristics of Current Transformers During Faults—II. **F. S. Rothe, C. Concordia**, General Electric Company

47-105. Short-Circuit Standards for Transformers. **A. N. Garin**, General Electric Company

DP.* Application of Capacitors for Power Factor Correction. **J. S. Williams**, Westinghouse Electric Corporation

D.P.* Series Capacitors for Welding Circuits. **W. C. Bloomquist, R. C. Wilson**, General Electric Company

10:00 a.m. Meeting of AIEE Board of Directors

2:00 p.m. Servomechanisms

DP.* Servomechanisms in Aerial Photography. **Roy C. Gunther, Jr.**, Boston University Optical Research Laboratory, Boston and Clark University

47–110. Solution of the General Voltage Regulator Problem by Electrical Analogy. **E. L. Harder**, Westinghouse Electric Corporation

2:00 p.m. Cables

DP.* Insulation Resistance Measurements With Particular Reference to Charging Current Errors. **E. W. Greenfield**, Anaconda Wire and Cable Company

DP.* Current–Time Curves in Insulation Resistance Measurements. **R. F. Field**, General Radio Company

DP.* Shielding in Electric Cable Insulation. **Victor Siegfried**, American Steel and Wire Company

2:00 p.m. Transportation

DP.* Recent Developments in Diesel-Electric Locomotives. **E. K. Bloss**, Boston and Maine Railroad

DP.* Radio Communication in Railroad Service. **L. J. Prendergast**, Baltimore and Ohio Railroad

3:30 p.m. Women's Program

Sightseeing trip to historic Wayside Inn with entertainment and dinner at the inn.

6:30 p.m. Social Hour

7:00 p.m. Smoker

● **PAMPHLET reproductions of author's manuscripts of the numbered papers listed in the program may be obtained as noted in the following paragraphs.**

● **ABSTRACTS of most papers appear on pages 401–02 of this issue and pages 89–90 of the January 1947 issue.**

● **PRICES and instructions for procuring advance copies of these papers accompany the abstracts. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.**

● **THE PAPERS regularly approved by the technical program committee ultimately will be published in "PROCEEDINGS" and "TRANSACTIONS"; essential substance of many will appear in "ELECTRICAL ENGINEERING."**

Thursday, April 24

9:30 a.m. General Session

Address of welcome by Vice-President E. W. Davis

Remarks on Institute affairs by President J. Elmer Housley

Discussion of organization of the engineering profession by J. F. Fairman, director of the AIEE and chairman of committee on planning and co-ordination.

Address: Atomic Energy—Some of Its Problems and Possibilities. **Harry A. Winne**, vice-president in charge of engineering policy, General Electric Company

12:00 p.m. District Executive Committee Luncheon

2:00 p.m. Industrial Applications

DP.* Electrical Applications in the Wire Industry. **J. G. Roby**, General Electric Company

DP.* Electrically Controlled Tension for Reeling Operations. **R. M. Scott**, New England Butt Company

47–35. Electric Equipment for 2-for-1 Twister. **E. C. Gwaltney, H. J. Burnham**, Saco-Lowell Shops

47-32. Electric Drives for Textile Finishing Ranges. **R. B. Moore, H. C. Uhl**, General Electric Company

DP.* Oxide Rectifiers as Power Supply for D-C Motors. **L. F. Reed**, Westinghouse Electric Corporation

2:00 p.m. Communications

47-109. An Improved Cable Carrier System. **H. S. Black, F. A. Brooks, A. J. Weir, I. G. Wilson**, Bell Telephone Laboratories, Inc.

47-111. New Test Equipment and Testing Methods for Cable Carrier Systems. **W. H. Tidd, S. Rosen, H. A. Wenk**, Bell Telephone Laboratories, Inc.

DP.* Carrier Current Systems on Power Transmission Lines. **L. G. Eaton**, New England Power Association

47-112. A New Single Side Band Carrier System for Power Lines. **B. E. Lenehan**, Westinghouse Electric Corporation

2:30 p.m. Women's Program

Sightseeing tour to Worcester Art Museum or Higgins Armor Museum followed by entertainment and tea.

6:30 p.m. Social Hour

7:00 p.m. Banquet

Friday, April 25

9:30 a.m. Applications to Machine Tools

DP.* Machine Tool Electrification as Influenced by the National Machine Tool Builders Electrical Standards. **A. L. Krause**, Brown and Sharpe Manufacturing Company

DP.* Application of High Frequency Electric Equipment to Machine Tools. **H. F. Penney**, General Electric Company

47-106. Adjustable Frequency Control of High-Speed Induction Motors. **G. W. Heumann**, General Electric Company

DP.* Magnetic Vibration in Motors. **R. C. Griffith, B. F. Hammarstrom**, Heald Machine Company

DP.* Electronic Motor Control for Milling Machine. **Mark Morgan**, Reed-Prentice Corporation

9:30 a.m. Student Session

A New Type of Phase Sequence Indicator. **Harold Hull, James Feltner**, University of Connecticut

A Simplified Resistance Tuned Oscillator and Multivibrator. **Ralph Carlson**, University of Connecticut

Theory and Application of Complex Vacuum Tube Voltmeter. **F. H. Stansfield**, Northeastern University

Electronic Fractional-Horsepower Torque Measuring Indicator. **R. O. Williams**, Northeastern University

A Compact 45-Kv Surge Generator. **M. J. Reilly**, Worcester Polytechnic Institute

A Circuit Breaker for General Household Use. **John Hambor**, Worcester Polytechnic Institute

An Electric Knockmeter for Internal Combustion Engines. **R. W. Husher**, Yale University

The Application of Circle Loci in the Solution of Electrical Problems. **W. J. Dornhoefer, Gordon C. Bill**, Yale University

12:00 noon. Student Branch Counselors' and Chairmen's Luncheon

1:30 p.m. Inspection Trips

The American Steel and Wire Company
Substation and central dispatcher's office of the New England Power Company at Millbury

The Norton Company; Heald Machine Company.

*DP. District paper; no advance copies available; not intended for publication in *TRANSACTIONS*.

Tower of Boynton Hall, administration building of Worcester Polytechnic Institute

WTAC is one of Worcester's four radio stations which may be inspected during the North Eastern District meeting

(*continued from page 390*)

ENTERTAINMENT

On Wednesday evening a social hour and smoker will be held in the main ball room. On Thursday evening, an informal banquet in the main ballroom will feature a speaker of prominence.

HOTEL RESERVATIONS

Members should make their own hotel reservations by writing directly to the hotel. For convenience, a room reservation card for the Sheraton is being sent to members within the District. The scale of prices for the Sheraton is shown below:

Single rooms: $3.00, $3.55, $4.10, $4.75.

Double rooms, double beds: $4.65, $5.20, $5.75, $6.85.

Double rooms, twin beds: $5.10, $5.75, $6.85, $7.95.

Reservations should be made at once. As hotel accommodations are still scarce, approximate time of arrival should be stated when the reservation is requested.

ADVANCE REGISTRATION

Members are asked to register in advance. This will assist the registration committee and save time on arrival. Registration card should be sent to A. L. Duna, chairman registration committee, American Steel and Wire Company, 767 Millbury Street, Worcester 7, Mass. A registration fee of $2 will be charged all nonmembers with the exception of Student Members and the immediate families of members.

COMMITTEES

Members of the District meeting committee are: T. H. Morgan, chairman; E. W. Davis, vice-president; Victor Siegfried, secretary; H. F. Brown; T. S. Gray; E. R. McKee; D. R. Percival; W. S. Scheering; G. R. Town; B. F. Hammarstrom, secretary–treasurer, Worcester Section. Chairman of the subcommittees for the meeting are: Victor Siegfried, technical program; L. S. Leavitt, inspection trips and transportation; F. J. Adams, entertainment; A. L. Duna, hotel and registration; E. R. McKee, student activities; Mrs. W. T. Peirce, ladies' program; W. W. Locke, publicity and printing; S. M. Anson, finance.

Prices Increased on Advance Copies of Papers

To bring prices into line with rising production and paper costs, a revision of prices for advance pamphlet copies of author's manuscripts of technical papers will become effective with the 1947 North Eastern District meeting papers; S. M. Anson, finance.

	At Headquarters or Meeting		By Mail	
Size	Members	Nonmembers	Members	Nonmembers
12 pages or less	15	30	20	35
16 pages	20	40	25	45
20 pages	25	50	30	55
24 pages	30	60	35	65
28 or more	35	70	40	75

Nation Honors Edison As Exemplifying American Spirit

From Rhode Island to California tribute was paid to the "wizard of Menlo Park" on the 100th anniversary of his birthday, February 11, by leaders of every walk of life, by others who had known Thomas Alva Edison in life, and especially by men of the electrical industry, who so well personify the truth of one speaker's reminder that "you would not be holding the position you hold, . . . would not be living the life you are living . . . if it were not for this man."

At dinners and meetings throughout the country, sponsored by the AIEE either singly or jointly with other groups, the genius of the great inventor was lauded as inspiration for citizens of a free democracy. A host of good stories surrounding the colorful personality of the inventor were related, and personal recollections of him retold. The influence of his contributions on every facet of industrial life was reviewed with fresh amazement by prominent speakers.

Attendance figures received from the 25 AIEE Sections reporting participation in such celebrations, varied from 50 to the 1,300 reported by the Georgia Section, the average being approximately 350.

NEW YORK

Most elaborate of the celebrations was in New York, N. Y., where a dinner held in the Waldorf Astoria Hotel and attended by the inventor's widow, son, and two of his grandsons, drew an attendance of 770.

The dinner under the auspices of the AIEE New York Section and 25 other organizations was telecast by *WRGB*.

The main address of the evening was made by Doctor Oliver C. Carmichael, president, Carnegie Foundation for the Advancement of Teaching, who summarized the ramifications of Edison's inventions in modern life. In illustrating the breadth of the inventor's interests, Doctor Carmichael mentioned particularly his venture into the separation of iron ore from low grade deposits on the East coast during the Spanish-American War.

Edison spent nine years at this, but, when the discovery of the rich Mesabi deposits made his business unprofitable, the inventor lost no time in quitting the field and turning his experience to a new method of making Portland cement.

Edison's versatility was demonstrated gainin his invention of iron molds by use of which he could pour a concrete low-cost house in six hours. Though this project was abandoned at the time because of the opposition of the building trades, his principles again are gaining popularity.

The fountainhead of Edison's genius was attributed by Doctor Carmichael in closing to the spirit of a man who could say at the end of a lifetime of unparalleled inventiveness that "so far as he could remember, he had never worked a day in his life."

Albert Goldman, postmaster of New York, presented Charles Edison, son of the inventor and ex-governor of New Jersey, with the first two sheets of commemoratory stamps sold in Milan, Ohio. Mr. Edison in his response employed the words his father had used at a dinner ar-

ranged by Henry Ford to celebrate the 50th anniversary of the electric light:

I am told that tonight my voice will reach out to the four corners of the world. It is an unusual opportunity for me to express my deep appreciation and thanks to you all for the countless evidences of your good will, I thank you from the bottom of my heart.

I would be embarrassed at the honors that are being heaped on me on this unforgettable night were it not for the fact that in honoring me you are also honoring that vast army of thinkers and workers of the past, and those who are carrying on; without whom my work would have gone for nothing.

If I have spurred men to greater effort and if our work has widened the horizon of men's understanding even a little and given a measure of happiness in the world, I am content.

Ralph H. Tapscott (F '29) was chairman for the evening and Gano Dunn (HM '45) was toastmaster. Telegrams were read from New York's Governor Thomas E. Dewey and Mayor William O'Dwyer, of New York. Miss Nadine Conner sang three of the inventor's favorite songs: "In the Gloaming," the "Jewel Song" from "Faust," and "O Promise Me."

Other guests seated at the two dais were:

Gwilym A. Price, president of Westinghouse Electric Corporation; AIEE President J. E. Housley; Edwin W. Hammer, an Edison Pioneer; Ernest R. Acker; Doctor Frank B. Jewett (HM '45) retired vice-president of the American Telephone and Telegraph Company; Admiral Thomas C. Kinkaid, United States Navy; Frank M. Tait (F '12) president and general manager, Dayton (Ohio) Power and Light Company; Harvey S. Firestone, Jr.; W. S. Gifford (A '16) president of the American Telephone and Telegraph Company; W. Winans Freeman; Milo Maltbie; Joseph L. Egan; Charles E. Wilson, president of the General Electric Company; Edward F. Barrett; Lieutenant Commander Frank B. Wilson, chief of communications, United States Navy; J. C. F. Coakley; J. P. Morrissey; Jacob T. Barron (F '27) vice-president, Public Service Electric and Gas Company; Peter Edison Sloane; Admiral F. E. M. Whiting, United States Navy; William H. Harrison (F '31) vice-president of the American Telephone and Telegraph Company; Hudson R. Searing (F '30) vice-president of the Consolidated Edison Company of New York, Inc.; Admiral Monroe Kelly, United States Navy; Doctor Harry Woodburn Chase, chancellor of New York University; Thomas Edison Sloane; Doctor Walter I. Slichter (F '12) professor emeritus of Columbia University; Spencer Eddy; C. W. Kellogg (M '23) retired president of the Edison Electric Institute; Frank J. McMullen.

PROVIDENCE

A gathering of approximately 400 members of the AIEE Providence Section and the Electrical League of Rhode Island and their male guests filled the ballroom of the Providence Biltmore Hotel to capacity for the Edison centennial dinner, February 11.

Principal speaker for the evening was Doctor Robert Bruce Lindsay, chairman of the department of physics at Brown University, Providence, whose subject was "Science, Curse or Blessing?" Messages also were read from two Edison pioneers in the Section territory, Harry F. Miller and Louis R. Wallis, who were unable to attend, and Governor John O. Pastore of Rhode Island made a brief speech.

Highlights of the life of Edison were shown in a short movie, and a transcription of his voice was broadcast over the public address system. As mementos of the occasion, each guest was presented with a bronze medal bearing the likeness of Edison and a facsimile of a page of the New York *Herald* of December 21, 1879, describing some of Edison's experiments on incandescent lighting.

Brayton D. Fisher, director of the Electrical League of Rhode Island, was chairman for the evening, and Harold P. Arnold, president of the league, was toastmaster.

SCHENECTADY

The centennial dinner held February 11, in the Hotel Van Curler in Schenectady, N. Y., boasted the most numerous attendance of Edison Pioneers who had worked with the inventor, six of them being present. The anniversary dinner, sponsored jointly by the AIEE Schenectady Section, the Schenectady Chamber of Commerce, and the Schenectady Engineering Council, was attended by 325 guests and was broadcast over station *WGFM*.

Principal speaker of the evening was Doctor Willis R. Whitney (A '01) founder of the General Electric Research Laboratory and friend and associate of Edison. Members of the General Electric 50-year club were guests at the dinner.

A formal address prepared in advance by Doctor Whitney was distributed to the diners, and Doctor Whitney proceeded to talk extemporaneously about the inventor, explaining about the undelivered speech: "You're sitting on it and can read it, if you like, at leisure."

Edison's example in self-education and initiative is wasted in modern life, Doctor Whitney stated, "because people generally are too lazy and too concerned about their own comfort."

"How did Edison get that way," he asked. "Well not through the school system. Edison was inquisitive—he asked so many questions in school that the teacher though him 'addled.' He read books and developed a mind of his own . . . . and he learned a most important thing—that a failure can be just as valuable as success."

In his prepared address Doctor Whitney declared that Edison "caught the spirit of scientific-research-for-service described by Francis Bacon over three centuries ago, and saw living itself as "primarily action."

One of Edison's hardest worked phrases, according to Doctor Whitney, was "time is of the essence."

Doctor Whitney, who had come closest to the inventor after he was made president of the Naval Consulting Board in 1915, recalled that it was Edison's energetic efforts that induced Congress to appropriate one million dollars for a Naval Research laboratory in 1916.

Mention was made of the fact that, while studying fluorescent salts for his fluoroscope, Edison had anticipated fluorescent lighting by putting some salt on the inner surface of an X-ray tube. Another typical lesser known research was his study of common weeds as possible sources of rubber.

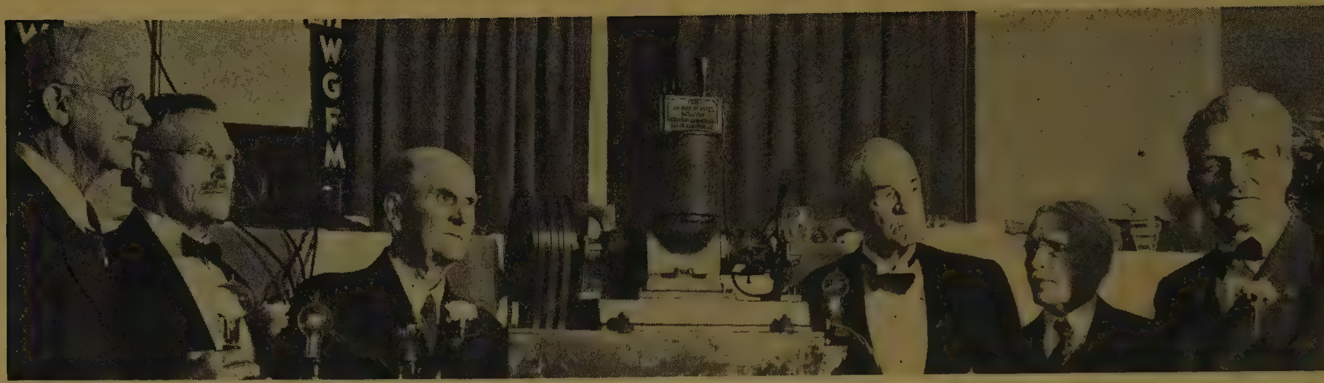
Other features of the Schenectady celebration were an address of welcome by Mayor Mills Ten Eyck; a demonstration of a bipolar dynamo, serial number 516, built in 1892, which furnished power to eight replicas of the Edison lamp at the speakers table; the comparison of an early Edison phonograph with a modern electronic reproducer; and a searchlight display in front of the hotel by two 60-inch 800-million-candlepower searchlights, operated by personnel from the Schenectady Army depot.

During the week of February 11, leading stores in Schenectady devoted their window displays to Edison memorabilia and station *WGY* broadcast a daily program recounting his life story.

CHICAGO

Fourteen other organizations joined with the AIEE in arranging a Chicago dinner

Shown (left to right) at the New York Edison dinner are his grandsons, Peter Edison Sloane and Thomas Edison Sloane; his widow, Mrs. Thomas A. Edison; R. H. Tapscott (F '29) chairman of the dinner; Gano Dunn (HM '45) toastmaster; C. L. Law, chairman of the arrangements committee; and the inventor's son, Charles Edison



The six Edison Pioneers at the Schenectady celebration were (left to right): J. H. T. Dempster (1886), John Weber (1890), Peter Kirsch (1886), F. P. Wilson (1891), A. T. Tinnerholm (1888), and David Miller (1891). In the center is the Edison bipolar dynamo

honoring the centennial of Edison's birth, which was held Monday, February 10, in the Palmer House. More than 500 engineers, business men, and technicians attended.

President Felix Van Cleef, of the Electrical Association of Chicago, presided. Introduction of the principal speaker, Charles Y. Freeman, chairman, Commonwealth Edison Company, was made by William O. Batchelder (A '08) vice-president of the General Electric Company. A narrative of the life of Edison illustrated with slides and some original motion picture films followed Mr. Freeman's address.

In his talk, Mr. Freeman discussed the significant contributions of Edison with particular emphasis on his contributions to the electric utility industry. He characterized the inventor as "a practical man who was a great natural mathematician, inordinately curious, and a marvelous experimenter" and quoted a not so well known Edison definition of genius as being 99 per cent "a knowledge of things that will not work."

He related an incident concerning two students who had worked unsuccessfully all night to determine the cubical content of the first incandescent lamp. Edison glanced at the problem, then he filled a duplicate of the lamp with water, poured the liquid into a glass graduate, and read off the answer for the students.

In discussing the accuracy of Edison's electric meter, Mr. Freeman told of an amusing encounter between Edison and the late J. Pierpont Morgan, who was one of the first customers of the Pearl Street Station in New York. Though he appreciated the advantages of electric light, the elder Morgan doubted the Edison meter. After the electric installation had been made in the Morgan banking house, Mr. Morgan had record cards attached to each fixture, and all employees were required to note the time each was in use. At the end of the month, the Edison meter showed a greater consumption of electricity than the cards. After several months unsuccessful trial, investigations by Edison revealed that the bank janitor, unaware of the timekeeping system, had found his cleaning made easier by the light of a 10-lamp fixture.

Samuel Insull, Mr. Freeman reminded his hearers, in assembling Chicago's numerous local light and power plants into a city-wide system, utilized effectively the training and engineering knowledge acquired through his long and intimate relationship with Thomas Edison.

DETROIT

In Dearborn, Mich., now the repository of Edison's Menlo Park laboratory, the inventor was honored on the morning of February 11, at which time the AIEE members in Detroit placed a wreath at the laboratory. A joint evening program of the Michigan Section and the Engineering Society of Detroit also paid tribute to Edison. The speaker of the evening was Ivan C. Crawford, dean of the college of engineering of the University of Michigan, Ann Arbor, whose subject was "The Engineer's Debt to Mr. Edison."

CONNECTICUT

A dinner meeting at the Seven Gables Towne House, New Haven, which 80 members and their wives attended, constituted the Connecticut Section's Edison centennial commemoration. An appropriate exhibit was furnished by the United Illuminating Company, the Connecticut Light and Power Company, and the Hartford Electric Light Company.

"Edison the Man" and the "Requirements in Engineering Education" were the topics of the main speaker, AIEE Vice-President Ernest W. Davis (F '34). Harold R. Bacon, president of the Derby Gas and Electric Company; E. J. Amberg (A '15) vice-president of the Connecticut Light and Power Company; and K. P. Applegate (A '14) vice-president of the Hartford Electric Light Company, also spoke briefly on the influence of Edison on modern life and of Institute indebtedness to him.

WORCESTER

At a joint meeting of the Worcester Section and Student Branch a sound film, "The Life of Thomas Edison," was shown to an audience of 60 persons.

Louis A. Leavitt (M '28) assistant manager of the Worcester County Electric Company, presented a short account of the inventor's life and accomplishments and then introduced George M. Hardy (M '20) vice-president of the company, who regaled those present with reminiscences of the early days of electricity in Worcester.

Professor T. H. Morgan (F '39) presided and was assisted by K. H. Truesdell, Branch chairman.

ROCHESTER

Edison's centennial anniversary was observed by the Rochester Section, at its February 6th dinner meeting, at which Thomas H. Yawger, an Edison Pioneer, was guest of honor.

PHILADELPHIA

A unique feature of the Edison centennial celebration of the Philadelphia Section was the presentation to the Section of a portrait of the inventor painted by D. E. Sutton, Jr. (A '43) engineer with the I-T-E Circuit Breaker Company.

Also part of the program February 10 were addresses by AIEE members who had known Edison and an exhibit of letters, photographs, and early models of Edison inventions. Two Edison pioneers and four later associates were guests of honor.

Edison's personal qualities were described by William Deans (F '30) chief engineer, I-T-E Company, who had known the inventor during World War I. Edison's accomplishments and benefactions to mankind, with special emphasis on his part in the founding and early work of the AIEE, were summarized by E. S. Lee (F '30) of the General Electric Company.

J. H. O'Brien, who was an office boy for Edison in 1889, and M. H. Hankins, who was hired by Edison as a glass blower in 1880, were the earliest associates present. Mr. Deans, I. M. Stein (F '39) vice-president of Leeds and Northrup Company; W. G. Walker (M '43) senior engineer, Philadelphia Electric Company; and H. S. Harris, secretary of the Engineers Club of Philadelphia; all were honored as later associates of Edison.

PITTSBURGH

The centennial meeting held by the Pittsburgh Section, February 11, opened with a motion picture, "Life of Thomas A. Edison."

J. T. Wilson, physicist, Allis-Chalmers Manufacturing Company, introduced his talk for the evening with a review of certain of the significant developments attributed to Edison and followed their evolution into the present-day progress of nuclear physics. The address was titled: "Solar Radiation and Its Effect on Power Transmission and Communication."

LEHIGH VALLEY

A review of Edison's life by Professor J. L. Beaver (F '26) of Lehigh University and a display of Edisoniana made up the program of the Lehigh Valley Section held February 14 to honor the memory of the inventor.

On display were a letter of May 25, 1912, from Edison to MacFarland Moore, a Lehigh University graduate, congratulating him on obtaining a position with the General Electric Company; the New York *Herald* for December 21, 1879, containing articles on Edison's light; and a contract for the lighting system of Sunbury, Pa., dated May 4, 1883, and bearing the signatures of Edison and Samuel Insull.

CLEVELAND

AIEE Past President W. E. Wickenden (F '39) addressed an audience of approximately 400 people at a joint meeting February 11 in the auditorium of the Cleveland Engineering Society of the AIEE Cleveland Section, the Illuminating Engineering Society, the Institute of Radio Engineers, and the Cleveland Engineering Society.

Doctor Wickenden dubbed the inventor "the culminating genius of a century of geniuses who, with only the rudimentary findings of sciences to aid them, transformed a rural and agricultural world into an urban and industrial world."

Of recent scientific methods, he said, "our generation had reversed the order of progress, putting research first and invention afterward, and in reversing the order the pace has been speeded immensely."

"The world always will need invention by direct deductive methods, to overcome the practical difficulties which science does not solve," he added. "But progress," he continued, "has ceased to wait for rare and unpredictable flashes of insight or strokes of genius. It has come to depend upon the orderly, co-operative efforts of ordinary men, directed into fruitful channels."

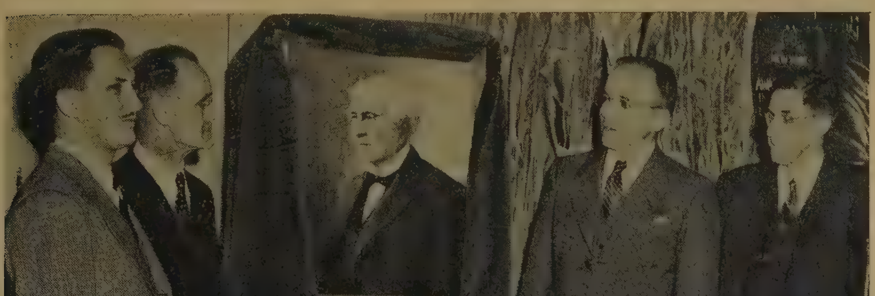
CINCINNATI

Edison was the keynote of the annual joint meeting of the Technical and Scientific Societies Council of Cincinnati held February 11 in the Taft Auditorium with an attendance of more than 1,000.

Speaker for the evening was David Sarnoff (M '23) president of the Radio Corporation of America, who took for his subject, "Science at New Altitudes." A dinner for Mr. Sarnoff preceded the meeting. Mayor Stewart of Cincinnati was a guest and a musical program was presented.

AIEE members on the joint meeting committee were: A. C. Burroway (M '37), W. H. McNutt (M '43), P. H. Goodell (M '46), J. L. Andrews (A '24), E. F. Nuezel (M '39), and G. K. Tashjian (A '43).

Placing the wreath at the Menlo Park Laboratory are, left to right, M. R. Horne (A '37); Fred Smith, curator of the Edison Museum; J. R. North (F '41); R. H. Underwood, Western Union Telegraph Company, Chicago, Ill.; L. W. Clark (M '42); C. Matzel, Ford Motor Company, Dearborn; C. R. Voorhess (A '15); E. C. Bowen, Western Union Telegraph Company, Detroit; C. J. Freund, dean, College of Engineering, University of Detroit; and G. M. Chute (M '33)



D. E. Sutton, Jr. (A '43) at the extreme left, shown with his portrait of Edison. With him are William Deans (F '30), H. A. Dambly (F '42), and E. S. Lee (F '30)

ST. LOUIS

The centennial of the birth of Edison was celebrated in St. Louis under the auspices of the St. Louis Section of AIEE and the Union Electric Company of Missouri.

A joint meeting of the St. Louis Section, the Student Branch of Washington University, the Illuminating Engineering Society, and the Institute of Radio Engineers opened the centennial activities on Monday evening, February 10, at Brown Hall, Washington University. Approximately 200 attended. The historic motion picture, "The Good Old Days," was shown, and J. W. McAfee, president of the Union Electric Company, described the preeminent position of Edison in the field of electricity.

To make the series of old "flicker" films more realistic a single projector was used, and the pauses between the reels were filled with sidelights on the great inventor. "The Great Train Robbery," produced by Edison at his West Orange, N. J., laboratory was the most interesting historically. In his speech, Mr. McAfee chose to consider Edison as a "tinkerer" rather than an inventor as the term in known today.

MILWAUKEE

A dinner meeting followed by a public program was held by the Milwaukee Section February 11 to observe the Edison anniversary. Members of the Engineers' Society of Milwaukee, the Institute of Radio Engineers, and the Illuminating Engineering Society also co-operated in the program.

At the dinner, Emil R. Lochman, of Milwaukee spoke informally of his association with Edison in 1912. The remainder of the evening's program comprised a motion picture on the life of the inventor, a speech by J. F. Reynolds of the A. J. Farnham Company on "Edison, the Third Son of February," and one by A. A. Engelhard whose topic was: "The Impact of Edison's Inventions on Present-Day Living."

AKRON

Through the offices of the Akron Section, the Merchants Association, the Superintendent of Schools, the Ministerial Association, and the Akron Public Library all gave some recognition to the Edison centennial celebration.

At the Section meeting, February 11, the pamphlet, "You Are the Heirs of Edison," was distributed. A. L. Richmond (A '16) gave a brief biographical sketch of the inventor, mentioning his friendship with Harvey Firestone and the fact that the

inventor had married an Akron girl. A silent film picturing Edison was shown. On display at the meeting were an early Edison generator loaned by the University of Akron, a section of very early underground cable, and group photographs of Edison, Firestone, and Henry Ford.

MADISON

Presentation of a paper on Edison was featured at the February 18 meeting of the Madison Section. Prepared and read by Professor Cyril M. Jansky (F '32) professor emeritus of the University of Wisconsin, the paper cited Professor Jansky's personal experiences in the transition from candles and kerosene lamps to electric lamps, as an example of the effect of Edison's inventions upon man's environment. Claiming that science and invention have spiritual values, Professor Jansky singled out Edison's phonograph, which brings the great symphonies to a wider audience, as an illustration. Edison's remarkable self-reliance was extolled as an example for the modern world. "His genius flowered in an atmosphere of individual initiative in a way it could not have developed under a dictatorship or a bureaucracy," the professor declared.

MINNESOTA

An evening meeting marking the Edison centennial was held February 11 by the AIEE Minnesota Section in the electrical engineering building of the University of Minnesota. Professor Henry E. Hartig (M '30) presided.

An exhibit of Edison relics was opened for inspection, and the item attracting most attention proved to be a type Z Edison generator, said to be among the first which Edison built. It was bought by Henry Villard in 1882 for lighting the *Kalama*, used to ferry railroad cars across the Columbia River, and the university secured it in 1920. The 65-year-old machine, belt driven, was brought slowly to rated speed (1,200 rpm) by an induction motor "to the accompaniment of a certain amount of fearful incredulity from the onlookers."

Other items on display were several early Edison line voltage indicators, plunger type ammeters, an Edison chemical watt-hour meter, and a variety of contemporary competitive as well as freak carbon filament lamps. All meters were authentic relics of the introduction of electric lighting to Minnesota. Several were in use at the university power plant prior to 1900, and one of the ammeters originally was installed in Pillsbury *A* flour mill in Minneapolis in 1885.

MARYLAND

To honor Edison, the AIEE Maryland Section joined with 14 other organizations in sponsoring a dinner in the Lord Baltimore Hotel, Baltimore, which was attended by 540 people. Doctor W. B. Kouwenhoven (F '34) of Johns Hopkins University, was toastmaster for the evening and opened the festivities with a brief sketch of Edison's career.

Merryle Stanley Rukeyser, financial editor of the Hearst newspapers, delivered the principal speech of the evening, "The Influence of Thomas A. Edison's Work on Present-Day Industry."

Replicas of several of Edison's inventions were exhibited and demonstrated. One of the highlights of the evening was the reproduction of Edison's voice speaking at the "Golden Jubilee of the Electric Light." This was done using a replica of his original phonograph.

Second Army headquarters participated in the event with a powerful searchlight display from the streets surrounding the hotel on February 10th and 11th. The Army also prepared an interesting display of communication and electric equipment in the lobby and mezzanine floors of the hotel. Guests were televised as they approached the entrance to the ballroom with television equipment provided by radio station *WBAL*.

VIRGINIA

Simultaneous meetings of the Richmond and Hampton Roads Subsections of the AIEE Virginia Section at Richmond and Norfolk, respectively, observed the Edison anniversary, February 11. The attendance figure at the two meetings amounted to about 65 members and guests.

The Richmond program featured two papers. R. Cooper Bailey (F '37) Virginia Electric and Power Company, dealt with "Thomas A. Edison—The Engineer." V. W. Berry, vice-president of the Virginia Transit Company, presented "Problems and Progress in Electrical Transportation."

At Hampton Roads the guest speaker was G. A. Carnegie, who worked closely with Edison for many years in the development of the transcribing and dictating equipment now known as the Ediphone. His informal talk and the subsequent discussion developed many interesting and intimate details of the life, character, and philosophies of the inventor. A number of photographs, several with Edison's long-hand notations, were shown. Llewellyn Saunders (M '32) presented an illustrated talk, "Engineering Evolution of Electrical Machinery," showing many pictures of electric machines from the earliest known attempts down to 1912. These pictures represented a small part of the large collection Mr. Saunders has acquired over a long period.

GEORGIA

Approximately 1,300 attended the centennial meeting in the Erlanger Theater, Atlanta, sponsored by the AIEE Georgia Section and the Southern Bell Telephone and Telegraph Company.

"Radar and Microwaves" by Doctor J. O. Perrine, assistant vice-president of the American Telephone and Telegraph Company, was the main speech of the evening. He demonstrated the propagation, reflection, refraction, and diffusion of 3-centimeter electromagnetic waves, the use of wave guides, and the like.

NEW ORLEANS

The AIEE New Orleans Section participated with the Electrical Association of New Orleans, in an Edison centennial dinner, February 21.

Attended by more than 500, the dinner was highlighted by an address by Charles Edison, son of the inventor, and by the presentation of Golden Anniversary Certificates to six local pioneers of the industry by A. B. Paterson (M '22) president, New Orleans Public Service, Inc. Many prominent local citizens, including the mayor, were present.

Charles Edison lauded the principle of free enterprise and emphasized the need for the individual to make his way by his own efforts, without help from government.

Featured at the banquet was a tableau of light, presented by the New Orleans Public Service, Inc., depicting the history of the development of light from candles to the most recent type of fluorescent lamp.

PORTLAND

The Portland Section of the Institute observed the centennial of the birth of Thomas A. Edison at a meeting held February 11, at which Francis H. Murphy (F '30) Portland consulting engineer, presented a short talk on the highlights of the life of Edison. This was supplemented by a sound film "The Life of Thomas A. Edison."

In addition, Charles P. Cabell, chemical engineer at the Hanford Engineering Works of the General Electric Company, addressed the group on the subject "The Engineering Aspects of Obtaining Energy by Nuclear Fission."

LOS ANGELES

Frederick Bedell (F '26) who knew Thomas Edison, talked on the early history of the electrical industry and the part taken by Edison in its development, at the centennial dinner meeting of the Los Angeles Section February 12.

SAN DIEGO

Leading city and county officials; high ranking Army, Navy, and Marine Corps officers; industrial leaders; and others prominent in the electric industry made up an audience of 275 at a centennial meeting honoring Edison held February 11 in the U. S. Grant Hotel, San Diego, Calif. The meeting was a joint one of the AIEE San Diego Section with the Electric Club of San Diego and the Bureau of Radio and Appliances of San Diego. Everyone attending was presented with a bronze medal commemorating the event. The program was broadcast over stations *KFMB* and *KFSD*.

S. D. Nesmith, ranking member of the Edison Pioneers, was present and received a radio set in appreciation of his interest in the community of San Diego, in which he now resides. Also present at the meeting was E. T. Price, president of the Solar Aircraft Company, who is the son of the late Edison Pioneer, C. R. Price, who worked with Edison in 1884 and was organizer and president of the New Bedford Edison Gas and Light Company in the early nineties.

L. M. Klauber (F '23) spoke on "Effects of Inventions of Thomas A. Edison on Modern and Future Living."

Results Tabulated on Engineering Organization Questionnaire

Some 1,450 AIEE members have expressed opinions and preferences for the type of organization which best would enable the engineering profession to disseminate technical information, to render a greater service to society, to maintain professional standards, and to enhance the public esteem and recognition of engineers. This survey has been completed and is published because of widely expressed interest in its outcome.

BACKGROUND

In September 1945, Doctor W. E. Wickenden, then AIEE president, instigated a thorough and searching study of the Institute's adequacy to meet the needs of its own members, possible future exigencies, and its relations with the profession-at-large. The professional activities subcommittee was formed to study various aspects of the problem and to make such recommendations to the committee on planning and co-ordination as seemed advisable "for changes in organization, improvement in methods, and amendment of scope." Members of the subcommittee are:

T. G. LeClair (F '40), *chairman;* M. S. Coover (F '42); W. S. Hill (F '39); B. D. Hull (A '41); F. E. Sanford (M '34); and G. B. Smedley (M '30).

Among the many subjects and problems considered was that of the adequacy and betterment of the present organization of engineers. Before attempting to offer any suggestions for a more suitable form of professional organization, the subcommittee wanted expressions of ideas and preferences from Institute members, particularly those with experience in the management of the local and District organizations.

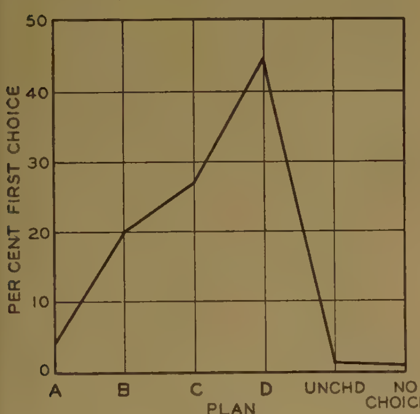


Figure 1. Which plan do you believe would carry on most effectively the professional activities common to all engineers and unite and strengthen the field of engineering as a profession?

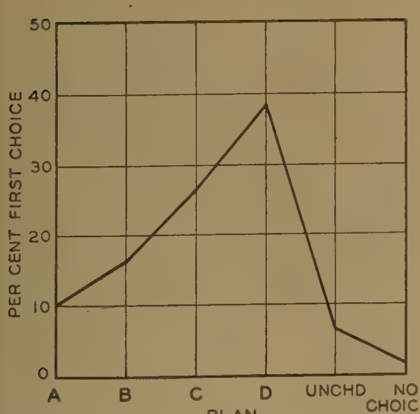


Figure 2. Which plan do you believe would carry on most effectively the educational work of guiding and training prospective members of the engineering profession?

SUBCOMMITTEE SURVEY

Four possible approaches to a more suitable organization were developed and described in a published progress report (*EE, Apr '46, pp 169–73*). Very briefly, the fundamental principle of each of the proposed plans is:

Plan A proposes consolidating the existing electrical engineering societies only into a new American Association of Electrical Engineers which would unite those practicing in all fields of electrical engineering more effectively than is possible with the several societies now in existence.

Plan B proposes that the existing engineering societies continue to function in technical matters and that a separate autonomous Engineering Profession Society of which all engineers would be members should carry on nontechnical or general activities of interest to engineers.

Plan C proposes a federation or council of all existing engineering societies to provide a single channel for consideration and action on all technical and professional matters of interest to engineers.

Plan D proposes the setting up of a new American Society of Engineers into which would be incorporated all of the existing societies. This one society would have all engineers as members and would function in all technical and professional activities involving engineers.

Unchanged Plan is the existing condition under which each branch of the profession is organized into one or more engineering societies which operate independently in the pursuit of a variety of professional, technical, and educational objectives.

A questionnaire was developed for use at local, District, and national meetings to get expressions from Institute members on these plans. Questions were designed to enable individuals to express their preference or opinions as to the effectiveness of the various plans in meeting the needs, common to all engineers, for organization of the profession. Information as to the status of the person answering the questions also was checked on each questionnaire. Though the number of questionnaires filled out was not large in comparison with the total number of Institute members, all types of meetings and all sections of the country were

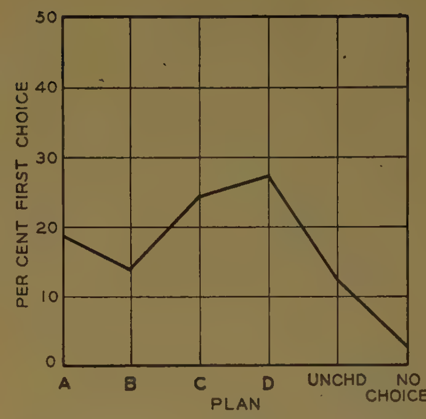


Figure 3. Which plan do you believe would carry on most effectively the technical activities for which existing technical societies were organized?

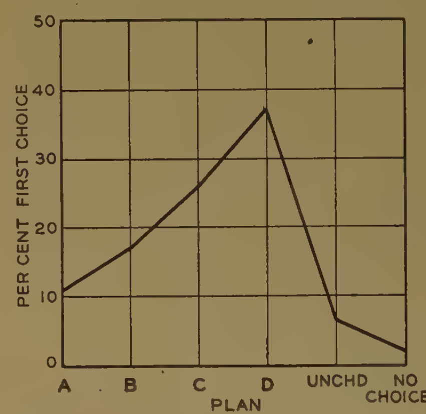


Figure 4. First choices on an over-all basis, as shown by all returns

covered. Sessions devoted to discussion of the problem, the proposed plans, and the filling out of questionnaires by individuals in attendance were held at the summer meeting in Detroit, Mich.; at the Pacific Coast meeting in Seattle, Wash.; at District meetings in Buffalo, N. Y. (District 1), Pittsburgh, Pa. (District 2), Asheville, N.C. (District 4), Indianapolis, Ind. (District 5), San Antonio, Tex. (District 7); and at 15 Section executive committee meetings and at more than 20 Section Meetings in various parts of the United States and Canada. In all, 1,450 questionnaires were returned to the subcommittee and are included in the results published. Information checked on the questionnaire forms as to status of education, registration, position held, specialized field of interest, and so forth showed a wide range of coverage. As there was very little change in accumulated results after about 500 questionnaires were returned, the subcommittee concluded that further sampling of opinion was of little value.

The subcommittee submitted the results of its survey and also recommended consideration of a new plan of organization, which was outlined in its report to the committee on planning and co-ordination, during the winter meeting in January 1947.

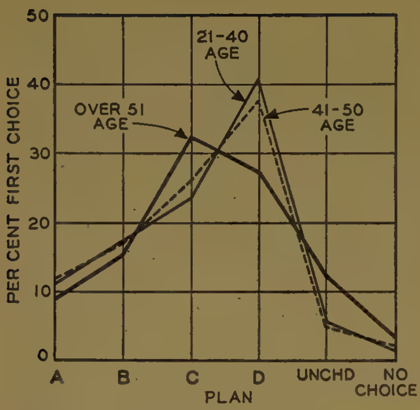


Figure 5. First choices on an over-all basis, shown by a separate analysis of each of three age groups

This committee approved the report and submitted it to the board of directors for action. Because of the interest among members throughout the country in this survey, the board of directors authorized immediate publication of the results of the survey and referred the remainder of the report to a special committee composed of the president and the four immediate past presidents for editing before publication.

RESULTS OF QUESTIONNAIRE

The questionnaire was divided into three portions, and the total preferences given for the respective questions are shown in Figures 1, 2, 3. A summation of preferences in all three divisions for the various plans, is shown in Figure 4. The replies were broken down and tabulated to show the preferences, on an over-all basis, of registered engineers, nonregistered engineers, and of those in three different age groups. The registered and nonregistered engineers did not indicate any marked differences in their preferences, but the variation of returns in the three age groups were significant. In general, it appears that the older engineers are more reluctant to see changes made in the present setup of autonomous technical societies. The first choices of the three age groups are shown graphically in Figure 5.

RECOMMENDATION

The returns of the questionnaire, including the many helpful comments, indicated a keen interest in and thoughtful consideration of the question of what would constitute the best type of co-operative organization of the engineering profession. As might be expected, quite a variety of suggestions were received—some going to extremes. But the great majority were to the effect that some changes were in order, so that the profession will be enabled to cope with new problems and situations more adequately. However, the returns also indicated that none of the proposed plans was acceptable to a majority of members without some modifications. Therefore, the subcommittee prepared a recommendation which takes into account not only the relative preference in favor of the four plans described, but also includes modifications as a result of the several hundred constructive comments received by letter and written on the questionnaire. The subcommittee's recommendation has been submitted to the board of directors with the approval of the committee on planning and co-ordination and is now in the hands of a special committee consisting of the president and the four immediate past presidents for editing before publication.

Summer General Meeting, Montreal, June 9–13, 1947

A program of wide-ranging technical interest with ample provision for entertainment, sports, and trips seems assured for the summer general meeting to be held in Montreal, Quebec, Canada, June 9–13. These features, combined with the conferences of officers, delegates, and members, and the annual meeting, will assure a busy profitable week. Headquarters of the meeting will be in the Mount Royal Hotel.

TENTATIVE TECHNICAL PROGRAM

Many of the technical papers will be of particular interest to members in eastern Canada, as they are related to industries in that region. In the industrial field there will be sessions on power supply and equipment in paper mills, and conferences on electrolytic conversion equipment and electric welding are in prospect. In the central station field, a session on hydroelectric power generation, three sessions on power transmission and distribution, as well as a session on transformers and a conference on dry-type transformers, will be arranged. Other conferences on operation of mercury-arc rectifiers and power system telemetering are in process of formulation, as well as a session on power system applications of carrier current. Another session will deal with problems in light traction, and still another under the sponsorship of the committee on safety will have papers on the hazards of static electricity in operating rooms and dust explosion in grain storage. The committee on education also is planning a conference on educational matters. Other technical sessions and conferences will be announced later.

ENTERTAINMENT

Evening entertainment will consist of a symphonic concert, smoker, reception to the AIEE president, and dinner dance. Accommodations for the smoker are limited to 1,000; hence, members are urged to make their reservations early. In addition to the afore-mentioned events, special entertainment will be provided for women, consisting of a sight-seeing tour and tea at the Botanical Gardens, a bridge, and a conducted shopping tour.

TRIPS

An endeavor is being made to schedule two airplane flights to Shipshaw during the afternoon of Wednesday, June 11.

Highlights of Saguenay Boat Trip

Friday, June 13, 6:00 p.m.—Boat leaves Montreal For those unable to be accommodated on Friday, arrangements will be made on a boat leaving Saturday evening.

Saturday, June 14, 5:00 p.m.—A trip to the Shipshaw Power Development has been arranged through the courtesy of the Aluminum Company of Canada.

Sunday, June 15—Stopover visits: 7:30 to 11:30 a.m.—Murray Bay. 3:30–8:00 p.m.—Quebec City.

Monday, June 16, 6:00 a.m.—Return to Montreal.

An orchestra will be on board for the trip.

As reservations will be filled in the order they are received, members are advised to make early application. Applicants should state whether or not they intend to visit the Shipshaw Plant. Hotel reservations also should be made as soon as possible. All requests for reservation should be addressed to: G. H. Gillett, secretary-treasurer, summer general meeting committee, AIEE; in care of Canadian General Electric Company, Ltd., 1,000 Beaver Hall Hill, Montreal, Quebec, Canada.

Sections Committee Organizes Projects for the Year

Summer meeting plans, extension of technical groups, Subsections, local engineering councils, and a new policy for prize papers were the main items on the agenda of the meeting of the AIEE Sections committee which met in New York January 28, with an attendance of 46.

Chairman G. W. Bower (M '40) presided with Vice-Chairman R. M. Pfalzgraff (M '41) and Secretary A. C. Muir (M '39) leading some of the discussion. AIEE President J. E. Housley (F '43) in a brief speech, praised the work of the committee in stimulating Section activity. He stressed the importance of the local Sections meeting the challenge of revolutionary changes in industry and noted that the activities of the Sections during his presidential trips around the country greatly exceeded that apparent when he was vice-president of District 4 a few years ago.

SUMMER PLANS

Tentative plans were formulated for the delegates meetings to be held at the summer general meeting in Montreal in June 1947. These tentative plans include a "get-together" luncheon of all the Section delegates and Institute board of directors prior to the conferences on Section operation and management.

Three conferences on Section operation and management following the pattern of the Detroit meetings will be held on the afternoon following the luncheon. These conferences will be devoted entirely to discussion from the floor. The annual meeting of Section delegates will be held the day after the conferences and the program of the meeting will include important phases of Section operation and management. A special conference on the operation of technical groups in the Sections also is planned for later in the meeting week.

After a general consideration of the organization and work of the Sections com-

mittee, it was the consensus of the meeting that a Sections committee representative should attend all meetings of the District executive committees.

TECHNICAL GROUPS

Development of technical groups in the Sections was reviewed. The number of such groups in active operation has increased to 104, with many additional groups in process of organization. A discussion of the co-operation of technical groups with the work of the technical committees of the Institute emphasized the need for a better geographical representation of Section members on the technical committees of the Institute. A plan for accomplishing this objective was developed in the meeting.

SUBSECTIONS

With 32 Subsections now in active operation, the Sections committee's promotional group has just completed making a survey of all Subsection possibilities, and many additional locations for Subsection operation have been disclosed by this survey. Subsections are being promoted in the possessions of the United States, with the San Francisco Section reporting one being organized in Honolulu, Hawaiian Islands; the New York Section reporting two Subsections being organized in Puerto Rico; and the Seattle Section reporting investigation of Subsection possibilities in Alaska.

LOCAL COUNCILS

An animated discussion developed on the program of the Sections committee for promoting the organization of local councils of engineering and technical societies where they do not exist, and encouraging the AIEE Sections to continue the active part they have taken. Several additional councils now are in process of being formed, and the Sections committee has been supplying much information in connection with the formation of these new councils.

PRIZE PAPERS

Indicating the great interest in prize paper activity among the Sections, several additional Sections have started prize paper contests. Mr. Bower advised that the special committee of the Institute has been working for the past three years in revising the prize paper rules. He is requesting that the new Institute publication policy recognize Section prize paper contests. A resolution was adopted unanimously requesting that the new prize paper rules be issued as soon as possible and that they provide for Section prize paper contests with suitable prize money available to the Sections conducting this activity.

SAFETY

In the discussion of the joint project between the Sections committee and the AIEE committee on safety for encouraging the presentation of the safety question in connection with Section meetings, it was asserted that the safety feature should be confined to the engineering phase of safety in connection with design, construction, operation, and maintenance of electric equipment.

Other subjects discussed at the meeting were:

Results of the conferences of Section delegates at the 1946 summer convention.

Section response to the questionnaire on the "Organization of the Engineering Profession."

Section meetings on maintenance of electric equipment in industrial plants.

The joint project between Sections and Student Branches.

The joint project between the Sections committee and the committee on education.

Section committee recommendation for a moving picture to be taken at the summer general meeting in Montreal for use by the Sections at their fall meetings.

Section finance.

Section publicity.

Formation of additional operating committees in the Sections with particular reference to a committee on transfers, advisory committee, suggestion committee, and finance committee.

News items and Section papers for publication in *ELECTRICAL ENGINEERING*

Among those present at the meeting were: Vice-Presidents F. L. Lawton and H. B. Wolf, Director D. A. Quarles, and Secretary H. H. Henline.

AIEE Electronic Tube Survey

A number of companies have not yet returned their AIEE questionnaire on "Survey to Determine the Need for Electronic Tubes with Special Characteristics" being sponsored by the joint subcommittee on electronic instruments. The subcommittee requests that all interested in this important subject assure themselves that their companies have completed and returned the form to AIEE headquarters, 33 West 39th Street, New York 18, N. Y.

Sectional Committee C42 Revising Electrical Definitions

Since the present edition of the "American Standard Definitions of Electrical Terms" was issued in 1941, there have been so many additions and changes in the terminology of electrical engineering, which in part have been accelerated by the war, that there is great need for a revision. A reorganized American Standards Association Sectional Committee *C42*, Definitions of Electrical Terms, has been appointed, and the work of revising the 1941 edition is well under way. The sectional committee is sponsored by the AIEE, with Professor Chester L. Dawes (F '35) of Harvard University, as chairman and J. J. Anderson, Jr. (A '40) of the Institute staff, as secretary. Thirty-three interested organizations are represented on the sectional committee, the total number of representatives being 55. The Institute representatives are J. E. Clem, C. L. Dawes, G. H. Garcelon, E. I. Green, E. B. Paxton, F. B. Silsbee, and C. F. Wagner.

The definitions are divided into 17 general categories in accordance with different fields of electrical engineering, and each category is assigned to a subcommittee. Under each subcommittee the definitions are subdivided into further classifications. The subcommittees, with their chairmen and the membership to date, are as follows:

Group 05—General (Fundamental and Derived) Terms
J. D. Tebo, *chairman*, Bell Telephone Laboratories, Inc.
E. Bennett, University of Wisconsin
J. G. Brainerd, University of Pennsylvania
L. W. Chubb, Westinghouse Electric Corporation
B. F. Lewis, Bell Telephone Laboratories, Inc.
W. A. Lewis, Armour Research Foundation
M. G. Malti, Cornell University
R. L. Sanford, National Bureau of Standards
B. R. Teare, Jr., Carnegie Institute of Technology
W. B. Kouwenhoven, Johns Hopkins University

Group 10—Rotating Machinery
E. B. Paxton, *chairman*, General Electric Company
C. M. Laffoon, Westinghouse Electric Corporation
S. H. Mortensen, Allis-Chalmers Manufacturing Company
M. S. Oldacre, Commonwealth Edison Company
O. E. Shirley, General Electric Company

Group 15—Transformers, Regulators, Reactors, and Rectifiers
V.M. Montsinger, *chairman*, General Electric Company
J. E. Clem, General Electric Company
E. V. DeBlieux, General Electric Company
I. W. Gross, American Gas and Electric Service Corporation
O. K. Marti, Allis-Chalmers Manufacturing Company
A. J. Maslin, Westinghouse Electric Corporation
W. C. Sealey, Allis-Chalmers Manufacturing Company
C. H. Willis, Princeton University

Group 20—Switching Equipment
H. J. Lingal, *chairman*, Westinghouse Electric Corporation
A. E. Anderson, General Electric Company
J. E. Clem, General Electric Company
H. C. Fitch, West Penn Power Company
W. A. Lewis, Armour Research Foundation
S. C. Leyland, Westinghouse Electric Corporation
W. J. Rudge, General Electric Company
H. E. Ruggles, Westinghouse Electric Corporation
H. P. Sleeper, Public Service Electric and Gas Company
R. M. Smith, Railway and Industrial Engineering Company
J. C. Woods, Commonwealth Edison Company

Group 25—Control Equipment
G. A. Caldwell, *chairman*, Westinghouse Electric Corporation

Group 30—Instruments, Meters, and Meter Testing
F. B. Silsbee, *chairman*, National Bureau of Standards
A. B. Craig, Boston Edison Company
C. L. Dawes, Harvard University
H. J. Fisher, Bell Telephone Laboratories, Inc.
I. F. Kinnard, General Electric Company
F. V. Magalhaes, Consolidated Edison Company of New York, Inc.
G. Thompson, Electrical Testing Laboratories
A. R. Rutter, Westinghouse Electric Corporation

Group 35—Generation, Transmission, and Distribution
C. F. Wagner, *chairman*, Westinghouse Electric Corporation
W. P. Holben, Duquesne Light Company
A. J. Krupy, Commonwealth Edison Company
W. A. Lewis, Armour Research Foundation
G. S. Lunge, General Electric Company
R. J. Wiseman, The Okonite Company

Groups 40, 41, and 42—Transportation
H. C. Griffith, *chairman*, Pennsylvania Railroad
A. H. Candee, Westinghouse Electric Corporation
K. H. Gordon, Pennsylvania Railroad
L. O. Grondahl, Union Switch and Signal Company
F. W. Harvey, Gibbs and Hill, Inc.
O. A. Keep, General Electric Company
J. D. Miner, Westinghouse Electric Corporation
K. R. Smythe, Glenn L. Martin Company

Group 45—Electromechanical Applications
M. A. De Ferranti, *chairman*, General Electric Company

Group 50—Electric Welding and Cutting
R. W. Clark, *chairman*, General Electric Company

Group 55—Illuminating Engineering
A. E. Parker, *chairman*, Worcester Polytechnic Institute

E. Q. Adams, General Electric Company
H. P. Gage, Corning Glass Works
K. S. Gibson, National Bureau of Standards
E. C. Huerkamp, Westinghouse Electric Corporation
H. Ives, Bell Telephone Laboratories, Inc.
K. B. Jackson, University of Toronto
L. A. Jones, Eastman Kodak Company
J. O. Kraehenbuehl, University of Illinois
W. F. Little, Electrical Testing Laboratories
M. Luckiesh, General Electric Company
P. Moon, Massachusetts Institute of Technology
H. Reinhardt, Sylvania Electric Products, Inc.
H. C. Rentschler, Westinghouse Electric Corporation
D. S. Robertson, Department of Transport (Canada)
M. M. Samuels, United States Department of Agriculture

Group 60—Electrochemistry and Electrometallurgy
G. W. Vinal, *chairman*, National Bureau of Standards
J. D. Edwards, Aluminum Company of America
P. V. Faragher, Aluminum Company of America
C. A. Gillingham, National Carbon Company
D. A. MacInnes, Rockefeller Institute for Medical Research
W. E. Moore, W. E. Moore and Company
S. Skowronski, International Smelting and Refining Company
J. G. Thompson, National Bureau of Standards
H. H. Uhlig, General Electric Company
J. L. Woodbridge, formerly, Electric Storage Battery Company

Group 65—Electrocommunication
E. I. Green, *chairman*, Bell Telephone Laboratories, Inc.
E. D. Becken, RCA Communications
W. D. Cannon, Western Union Telegraph Company
G. H. Gray, International Standard Electric Corporation
L. J. Prendergast, Baltimore and Ohio Railroad
H. R. Reed, Stromberg-Carlson Company
H. I. Romnes, American Telephone and Telegraph Company
J. C. Schelleng, Bell Telephone Laboratories, Inc.
A. B. Smith, Associated Electric Laboratories

Group 70—Electronics
S. B. Ingram, *chairman*, Bell Telephone Laboratories, Inc.

Group 75—Radiology
R. R. Newell, *chairman*, Stanford University Hospital
G. Laurence, National Research Council (Canada)

Group 80—Electrobiology
W. B. Kouwenhoven, *chairman*, Johns Hopkins University

Group 95—Miscellaneous
R. L. Lloyd, *chairman*, National Bureau of Standards
A. Coggeshall, Hatzel and Buehler, Inc.
S. B. Graham, American Telephone and Telegraph Company

It is intended that the definitions apply only to fundamental electrical and associated physical quantities and to the different types of electric apparatus and equipment that are in general use. It is not intended that they be either specifications or codes.

Every effort also is being made to bring these definitions and those in the standards of other societies into accord with one another. This is being done through the liberal appointment of representatives of other societies to the ASA subcommittees.

Institute members and others who are interested are urged to study the present definitions with the object of suggesting changes or making additions. Suggestions should be sent, in duplicate, to J. J. Anderson, Jr., Secretary, Sectional Committee *C42*, AIEE headquarters, 33 West 39th Street, New York 18, N. Y.

Portland Section Aids With Professional Exam

A study course, sponsored by the educational and student guidance committee of the AIEE Portland (Oreg.) Section and designed to prepare applicants for the professional registration examination in March 1947, has resulted in 20 applications for membership in the Institute.

Started early in November 1946 with a registration of 122, the weekly classes have maintained an attendance of 109. Of the 70 who are expected to take the examination, about 77 per cent are AIEE members or applicants for membership.

Instruction and discussion at the classes are under the leadership of someone, usually from the class, who is a specialist in the field of electrical engineering being studied. Additional small study groups meet once

When the AIEE Michigan Section held a past chairmen's night January 14 in Detroit, 29 past chairmen, or all but one of the 30 now living, attended. Formed in 1911, the Section has had 35 chairmen. L. F. Hickernell, of New York, N. Y., was the only one who attended from outside Michigan. Reminiscences by J. J. Woolfenden, who was active in the formation of what at first was called the Detroit–Ann Arbor Section, were a high point of the evening's program. The past chairman shown are: First row (left to right): D. H. Baker (1938), M. B. Stout (1943), H. P. Seelye (1936), E. V. Sayles (1941), D. E. Hauser (1933), F. H. Riddle (1928), Harold Cole (1927). Second row: L. Braisted (1931), A. H. Lovell (1929), F. L. Snyder (1925), A. A. Meyer (1917), G. E. Lewis (1919), H. H. Higbie (1918), J. J. Woolfenden (1913), J. H. Cannon (1923). Last row: A. S. Albright (1922), L. F. Hickernell (1930), G. B. McCabe (1926), S. M. Dean (1942), J. R. North (1935), M. M. Cory (1945), J. W. Bishop (1944), R. E. Greene (1939), W. G. Knickerbocker (1940), E. L. Bailey (1924), J. J. Shoemaker (1932), S. S. Attwood (1937), L. W. Clark (1946), R. Foulkrod (1934)

each week to work and discuss representative problems.

Meeting place, instructors, and a collection of study problems were provided by the Section at a small charge to members and applicants and a somewhat greater fee for nonmembers.

Pittsburgh Section Holds Midwinter Meeting

The 20th annual midwinter dinner meeting and Student Branch conference of the Pittsburgh Section was held jointly with the electrical section of the Engineers' Society of Western Pennsylvania at the Keystone Hotel, Tuesday, January 14, 1947. The attendance was the largest in the history of the meeting.

J. B. Hodtum (M '26) chairman of the Section, presented the following distinguished members and guests of the Institute: J. Elmer Housley, AIEE president, and C. A. Powel (F '41) past president, of AIEE; E. S. Fields (F '29) vice-president, Cincinnati Gas and Electric Company and vice-president District 2; E. C. Stone (F '31) vice-president, Duquesne Light Company and past vice-president of the Institute; C. M. Laffoon (F '45) AIEE director; W. R. Work (F '40) assistant director of the College of Engineering and Science, Carnegie Institute of Technology, and past chairman of the Section; H. E. Dyche (F '42) head electrical engineering department, University of Pittsburgh, and past chairman of the Section; B. M. Jones (F '42) past chairman and Section historian; E. A. Walker (M '41) head, electrical engineering, Pennsylvania State College; A. H. Forman (F '43) head, electrical engineering department and student counselor for West Virginia University; J. F. Reuther, University of Pittsburgh Student Branch; R. D. Wycoff, chief geophysicist, Gulf Research and Development Company; Thomas D. Jolly, vice-president and chief engineer, Aluminum Company of America; M. W. Smith (F '42) vice-president, Westinghouse Electric Corporation; A. N. Cartwright (M '41) vice-president, West Penn Power Company; J. F. Cox, vice-president and general manager, Western area, Bell Telephone Company of Pennsylvania; Joseph Bryan, manager, General Electric Company, Pittsburgh; Samuel Horelick (M '41) president, Pennsylvania Transformer Company; Percy Cook (A '20) chief engineer, Northside Works, Allis-Chalmers Manufacturing Company; and R. B. Fulton (A '44) representing the Engineers' Society of Western Pennsylvania.

President J. E. Housley addressed the meeting on the subject of "Industry and the Institute." J. F. Reuther presented a very interesting report on the Student Branch conference, participated in by 168 students of the electrical engineering departments of Carnegie Institute of Technology, University of Pittsburgh, Pennsylvania State College, and West Virginia University. Technical papers were presented, and an inspection trip was made through the Aluminum Research Laboratories in New Kensington.

The history of the Pittsburgh Section was reviewed briefly by B. M. Jones who pointed out that it was the second to be formed, following the Minnesota Section in 1902 by only six months. Six of the Institute's presidents have been members of the Pittsburgh Section. Ten of its members were medalists. The Pittsburgh Section is fourth in membership, having reached a maximum of 885 members in 1926–27, and having 693 members at the present time.

AIEE President Visits Louisville. President J. Elmer Housley delivered an illustrated address at the AIEE Louisville (Ky.) Section in November. On that occasion, Mr. Housley also met with students of Speed Scientific School of the University of Louisville and discussed the problems of the engineer and the affairs of the Institute. Several days afterwards, Mr. Housley held a similar conference with students at the University of Kentucky, Lexington.

STUDENT BRANCH

Students Commended. Members of the eight Student Branches who assisted in supervising the technical and conference sessions at the winter meeting were praised highly by the 1947 winter meeting committee. According to the committee, the largest attendance on record for a New York meeting "was handled in a most satisfactory and orderly manner due, in no small degree, to the able services of the Student Members." The co-operating Student Branches were those at Polytechnic Institute of Brooklyn, Columbia University, Cooper Union, Manhattan College, Newark College of Engineering, the College of the City of New York, New York University, and Pratt Institute.

ABSTRACTS

prepared by the authors of the papers and approved by the technical program committee.

TECHNICAL PAPERS previewed in this section will be presented at the AIEE North Eastern District meeting, Worcester, Mass., April 23–25, 1947, and will be distributed in advance pamphlet form as soon as they become available. Members may obtain copies by mail from the AIEE order department, 33 West 39th Street, New York 18, N. Y., at prices indicated with the abstract; or at five cents less per copy if purchased at AIEE headquarters or at the meeting registration desk. Prices for nonmembers will be as given on page 392.

Mail orders will be filled
AS PAMPHLETS BECOME AVAILABLE

Carrier Current

47-112—A New Single Side Band Carrier System for Power Lines; *B. E. Lenehan (A '24). 20 cents.* A solution for the noise and frequency crowding problems in the power-line carrier field is presented in the form of a new single side band carrier system which is continuously adjustable in frequency. Signal and carrier frequencies are split into polyphase components by wide frequency-range phase-splitting circuits and the components recombined through linear copper-oxide modulators into a single side band signal which can be amplified to the required power. Performance curves for the phase-splitting circuit and modulators are included.

Communication

47-109—An Improved Cable Carrier System; *H. S. Black (F '41), F. A. Brooks (A '36), A. J. Wier (A '36), I. G. Wilson. 25 cents.* A new and more economical 12-channel cable carrier system is described which is suitable for transcontinental distances. Important features are negative feed-back amplifiers of improved design, new arrangements for accurate equalization of the cable loss, and novel types of automatic thermistor regulators which continuously control the transmission of each system.

47-111—New Test Equipment and Testing Methods for Cable Carrier Systems; *W. H. Tidd (A '31), S. Rosen, H. A. Wenk. 20 cents.* Three portable test sets developed for the improved cable carrier system are described:

1. A selective heterodyne-type transmission measuring set covering 10 to 150 kc with a sensitivity of 95 decibels below one milliwatt in 135 ohms, an 8,000-ohm input impedance to permit bridging measurements, and a 50-cycle nominal band width.

2. A resistance-capacitance oscillator with a decade system of setting frequencies from 2 to 79 kc. The Wien bridge circuit is used. Frequency accuracy is better than 0.1 per cent. Maximum output is 16 decibels above one milliwatt.

3. A vacuum tube test set for testing tubes used in the system, which measures dynamic transconductance, peak plate current when the grid is driven to zero bias, the change in these when filament voltage is reduced 10 per cent, plate and grid current, and maximum power output.

Testing methods for the cable carrier system are discussed briefly.

Electric Machinery

47-105—Short-Circuit Standards for Transformers; *A. N. Garin (M '37). 20 cents.* The American Standards on short circuits are clear when applied for balanced 3-phase short circuits on 2-winding transformers. They are subject to misinterpretation and may be misleading when applied for 3-winding units, particularly for unbalanced faults on units with stabilizing windings when these windings have no definite continuous kilovolt-ampere rating. This paper points out that there is no fixed relation between the continuous kilovolt-ampere ratings of windings and their thermal and mechanical ability to withstand short circuits. The ability of windings to withstand short circuits should be specified by giving them "short-circuit

ratings" of so many kilovolt-amperes for so many seconds. In conclusion, recommendations are submitted for a revision of the American Standards on short circuits and for addition of rules specifying the minimum permissible short-circuit rating for stabilizing windings, and for other reduced capacity windings, in multiwinding units.

Electronics

47-108—The Measurement of Acceleration With a Vacuum Tube; *Walter Ramberg. 25 cents.* Acceleration may be measured with a vacuum tube consisting of a fixed cathode and two plates, one on each side of the cathode. The plates are mounted elastically to deflect in response to acceleration normal to the plane of the plates. Displacement of a plate alters the electron current delivered from the cathode to that plate. A tube of this type is described, which has a natural frequency of about 800 cycles per second and a flat response for sinusoidal accelerations up to 200 cycles per second. The output at acceleration of 10*g* is sufficient to drive a high-frequency recording galvanometer directly without the complications of an amplifier. The advantages and limitations of this type of accelerometer are discussed.

Industrial Control Devices

47-106—Adjustable Frequency Control of High-Speed Induction Motors; *G. W. Heumann (M '46). 25 cents.* The simplest type of electric motor available to industry is the squirrel-cage induction motor. Such motors, when connected to commercial constant frequency lines, are constant speed motors. Speed control can be gained by adjusting the frequency and voltage applied to the motor primary. By raising the primary frequency above 60 cycles, higher speeds than 3,600 rpm are possible, and motors can be built for speeds up to 80,000 rpm and 1,330 cycles. Conversion equipment is required to produce the adjustable frequency power applied. Two types of machines have been used, synchronous alternators and induction frequency converters. Frequency control of the adjustable frequency system is obtained by speed control of the converter set. D-c shunt motors with adjustable voltage control by means of amplidyne or electronic exciters have been applied successfully. Speed regulators are described which permit maintaining converter set speed and the frequency within narrow limits. To make a given adjustable frequency system usable for induction motors of various sizes and types of manufacture, volts per cycle should be maintained over the range of frequency and load for which a given induction motor is designed. Volts per cycle control on the adjustable frequency system is obtained by control of the synchronous alternator voltage or by control of the primary voltage of the induction frequency converter. Amplidyne or electronic exciter controls have been used for this purpose. While adjustable frequency systems for speed control of induction motors so far have found their principal field of application in the aviation industry, the control system described is general in its usefulness and could be used in other industries wherever the problem of control and regulation of high speeds exists.

Protective Devices

47-107—Transient Characteristics of Current Transformers During Faults—II; *F. S. Rothe (A '36), C. Concordia (F '47). 20 cents.* This paper presents results of a differential analyzer study of current transformers connected for bus differential protection. It is shown that the addition of impedance in the relay circuit extends the range of conditions under which standard current transformers can be used.

Servomechanisms

47-110—Solution of the General Voltage Regulator Problem by Electrical Analogy; *E. L. Harder (M '41). 35 cents.* The transient performance of a generator voltage regulating system is the terminal voltage, as a function of time, following a voltage disturbance or following the sudden addition of load. The general quantitative solution to this problem is given for linear systems in terms of the parameters of the system. These are the time constants of the generator, exciters, and damping transformers and the over-all voltage amplification. The data cover systems of up to three delays and were obtained by calculation and by the use of the servo analyzer, an analogue type of computer for analyzing regulating systems. The paper reviews the problem, describes the servo-analyzer method of solution, and gives the general solution, with interpretations.

PERSONAL • • • •

K. T. Compton

Karl Taylor Compton (F '31) president of Massachusetts Institute of Technology, Cambridge, has received the Washington Award for 1947 "for his scientific and engineering activities, which have contributed considerably to the happiness, comfort, and well being of humanity." Doctor Compton was born September 14, 1887, in Wooster, Ohio, and received the degrees of bachelor of philosophy, 1908, and master of science, 1909, from Wooster College and the degree of doctor of philosophy from Princeton University in 1912. He was a member of the Wooster College and Reed College (Portland, Oreg.) faculties before becoming assistant professor of physics at Princeton (N. J.) University in 1915. He was chairman of the department of physics at Princeton University when, in 1930, he was appointed president of the Massachusetts Institute of Technology. Among the contributions he has made to that institution is the reorganization of its academic administration into schools of science, engineering, architecture, and industrial cooperation. During his presidency the Wright brothers wind tunnel has been built, and a laboratory for gas turbine research, the Sloan Automotive Laboratory, the Van de Graaff high voltage generator laboratory, a cyclotron, and a laboratory for the development of high voltage short wave X-ray generators have been established. The George Eastman Laboratories of physics and chemistry have been planned, and facilities for education and research established. At present Doctor Compton is also temporary chairman of the committee on guided missiles of the Joint Research and Development Board of the War and Navy Departments. Besides his educational activities, Doctor Compton has served on many scientific, governmental, and philanthropic committees and agencies. Among those benefiting from his recent wartime service were: the Baruch Rubber Survey Committee, the National Defense Research Committee of the Office of Scientific Research and Development, and the Secretary of War's Special Advisory Committee on the Atomic Bomb. He also served the OSRD's Chief Office of Field Service and later the OSRD's Scientific Intelligence Mission to Japan. He was chairman of the Joint Chief of Staff's Evaluation Board on Atomic Bomb Tests and is chairman of the President's Commission on Universal Training. Doctor Compton has been honored many times with the honorary degrees of doctor of science, doctor of laws, and doctor of engineering.

John Bayfield MacNeill (A '18, M '36, F '42) manager of the switchgear and control division, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been awarded the AIEE Lamme Medal for 1946 for "his foresight, leadership, and creative contribution in the development of switching equipment." Born June 21, 1888, in Summerside, Prince Edward Island, Canada, Mr. MacNeill was graduated from Massachusetts Institute of Technology in 1913. His first assignment with the Westinghouse Corporation was that of engineer on circuit breaker design from 1913 to 1918, and in the latter year he was placed in charge of the circuit breaker design sec-

J. H. Berry

B. D. Hull

J. B. MacNeill

W. I. Slichter

tion, becoming manager of the department in 1928. He was made general manager of the distribution engineering department in 1933 and manager of the New England engineering department in 1935. Later in 1935 he became manager of the switchgear engineering department and in 1944 manager of the switchgear and control division. Under Mr. MacNeill's supervision 1,500,000-kva indoor powerhouse circuit breakers were developed, and the commercial application of the deion principle was accomplished. He represented the National Electrical Manufacturers Association at the World Power Conference in Berlin, Germany, in 1930. He also served on the AIEE committee on power transmission and distribution from 1933 to 1935, and for many years on the committee on protective devices of which he was chairman for 1943–44. More than two dozen patents have been issued in his name.

Blake D. Hull Nominated for AIEE President

Blake D. Hull (A '15, M '26, F '39) chief engineer, Southwestern Bell Telephone Company, St. Louis, Mo., has been nominated for AIEE president. He was born September 12, 1882, in Galesburg, Mich., and was graduated from the University of Kansas in 1905. He immediately became assistant construction engineer for the Missouri and Kansas Telephone Company, Kansas City, Mo., and in 1910 was appointed transmission and protection engineer. When the company was absorbed by the newly formed Southwestern Bell Telephone Company in 1912, Mr. Hull was transferred to St. Louis and made general transmission and protection engineer for the entire area of the new company. He was named general building and equipment engineer in 1925 and area engineer for Texas in 1926. In 1936 he was appointed chief engineer for the company. Mr. Hull will retire from active service in October 1947. During World War II Mr. Hull was with the Construction Section of the Office of Production Management for more than a year and subsequently served for a year as consultant for the Defense Plant Corporation. Mr. Hull's AIEE activities have been numerous. He was chairman of the St. Louis Section for 1925–26 and served as director of the Institute from 1931 to 1935. He was vice-president for the South West District from 1928 to 1930. While in that office he was instrumental in the establishment of Sections in Dallas, Houston, and San Antonio, Tex.; and in the reorganization of the Oklahoma Section as the Oklahoma City Section. In 1944 he was general chairman of the summer meeting committee and has served on the following AIEE committees: communication, nominating, Institute policy, and transfers. At present he is a member of the committee on transfers and the subcommittee on professional development. He is a member of the Engineers Club of St. Louis.

W. I. Slichter Renominated for Office of AIEE Treasurer

Walter Irvine Slichter (A '00, M '03, F '12) professor emeritus of electrical engineering, Columbia University, New York, N.Y., has been renominated AIEE treasurer for the 18th time. Born in St. Paul, Minn., Professor Slichter was graduated from Columbia University in 1896. After an interim of seven years with the General Electric Company, Schenectady, N. Y., he returned to Columbia University as professor and head of the department of electrical engineering. He has been professor emeritus since 1941. Professor Slichter has given many years of service to AIEE committee work and currently is a member of the Institute committees on the Edison Medal, Members-for-Life Fund, Standards, and applications of electricity to therapeutics.

Berry, Bower, Cone, Ellestad, Geiger Nominated Vice-Presidents

Joel Halbert Berry (A '22, M '31, F '46) district manager, Virginia Electric and Power Company, Norfolk, has been nominated as AIEE vice-president for the Southern District (4). Mr. Berry, who was born January 3, 1889, in Blue Mountain, Miss., received the degree of bachelor of science in 1911 from Mississippi College and the degree of bachelor of science in electrical engineering from Georgia School of Technology in 1913. He spent two years in the testing department of the General Electric Company at Schenectady, N. Y., and Pittsfield, Mass., and in 1915 became efficiency engineer with the Hampton (Va.) Power Station. He was transferred to Annapolis, Md., as engineer on the Annapolis Short Line in 1917 and, after an interlude with the Hampton station in 1919, became chief engineer for the Annapolis Short Line. He served overseas with the 37th Engineers during the first World War. He was made production engineer of the Reeves Avenue station of the Virginia Electric and Power Company in 1921. In 1923 he was appointed chief engineer of power stations and substations of the company and in 1928 was appointed superintendent. He was transferred to the electric department in 1935 as assistant manager, becoming superintendent in 1939 and district manager in 1944. Mr. Berry has served as secretary and chairman of the Virginia Section, as District Secretary, and as chairman of the Hampton Roads Subsection. He is a former president of the Engineers Club of Hampton Roads.

George Washington Bower (A '18, M '40) engineer on special assignment, Public Service Electric and Gas Company, Newark, N. J., has been nominated as AIEE vice-president for the Middle Eastern District (2). Mr. Bower, who was born February 22, 1894, in Philadelphia, Pa., was graduated from Drexel Institute of Technology in 1914. He immediately became a draftsman at Camden, N. J., for the Public Service Company and was named district chief clerk in 1917, district foreman in 1919, and local field engineer in 1924. He was appointed district superintendent in 1927. In 1940 he was transferred to the general office in Newark on special assignment. Mr. Bower has served on the AIEE membership committee and currently is serving on the committees on planning and co-ordination and on Sections, of which he has been chairman since 1943. He has held many offices in the Philadelphia Section and was chairman of the Section for 1942–43. He has been AIEE representative on the Technical Societies

Council Co-ordinating Committee since 1945, as well as AIEE member on the Engineers' Joint Council Committee to Study the Organization of the Engineering Profession. He also served on the special Institute committees on Sections manual and on the review of practices in award of Institute prizes. He is a member of the Engineers' Club of Philadelphia, the Electrical League of South Jersey, and the Foreman's Club of South Jersey.

Donald Issac Cone (A '15, M '24, F '42) transmission and protection engineer, Pacific Telephone and Telegraph Company, San Francisco, Calif., has been nominated as AIEE vice-president for the Pacific District (8). Born July 30, 1891, in Eureka, Calif., Mr. Cone received the degree of bachelor of science in electrical engineering from the University of California in 1913 and has been with the Pacific Company ever since. Until 1918 he was engaged in field research investigations of electrical effects of power lines on telephone lines. He became protection engineer in 1919 and transmission and protection engineer in 1926. He was an instructor in the Bell System school in 1923 and in 1924 and 1925 had charge of an inspection of the company's lines conducted by the California Railroad Commission. He was chairman of the AIEE San Francisco Section for 1926–27 and has been chairman of the San Francisco Advisory Committee of the Engineering Societies Employment Service since 1945. He is a member of the Institute of Radio Engineers, the Acoustical Society of America, the Engineers Club of San Francisco, the San Francisco Electric Club, Phi Beta Kappa, Sigma Xi, Tau Beta Pi, and Eta Kappa Nu. He is the author of several technical papers.

Irwin Martin Ellestad (A '24, M '46) transmission engineer, Northwestern Bell Telephone Company, Omaha, Nebr., has been nominated for AIEE vice-president for the North Central District (6). Born in Lanesboro, Minn., December 5, 1895, he received the degrees of bachelor of science in 1922 and master of science in 1923 from the University of Minnesota. He joined the air service of the United States Army during the first World War. In 1923 he entered the plant department of the Northwestern Telephone Company, Minneapolis, Minn., and in 1926 was transferred to the chief engineer's department of the company in Omaha. He was with the transmission section of the department of operation and engineering of the American Telephone and Telegraph Company, New York, N. Y., from 1928 to 1933. Since 1936 Mr. Ellestad has been with the chief engineer's department of the Northwestern Company in Omaha. Mr. Ellestad was chairman of the AIEE Nebraska Section for 1938–39, AIEE District secretary (6) for 1939–41, and has been secretary of the Nebraska Section since 1942. He also is a member of Sigma Xi and the Engineers Club of Omaha.

Donald George Geiger (A '25, M '36) transmission engineer, Western area, Bell Telephone Company of Canada, Toronto, Ontario, has been nominated as AIEE vice-president for the Canada District (10). Mr. Geiger, who was born in Ottawa, Ontario, October 19, 1900, received the degree of bachelor of science in electrical engineering in 1922 and the degree of bachelor of science in mechanical engineering with honors in 1923 from Queens University. After a year as lecturer at Queens University, Kingston, Ontario, he joined the Montreal, Quebec, office of the Bell Telephone Company as engineer in the transmission department in 1924. From 1926 to 1928 he was again lecturer at Queens University, returning in 1928 to his position with the Bell Company. In 1930 he was appointed transmission engineer for the Eastern area of the company and later that year was transferred to Toronto as transmission engineer for the Western area. He was chairman of the AIEE Toronto Section for 1939–40 and has served on the AIEE committee on communication and on the nominating committee. He represents the Canada District of AIEE on panel *A* of the Canadian Radio Technical Planning Board. In 1935 Mr. Geiger received the best paper award for the Toronto Section and the Canada District. He is a member of the Institute of Radio Engineers, the Engineering Institute of Canada, the Association of Professional Engineers of Ontario, and the Council of Queens University.

Everitt, Monteith, Robertson Nominated for Directorships

William Littell Everitt (A '25, M '31, F '36) professor and head of the electrical engineering department, University of Illinois, Urbana, has been nominated to serve on the AIEE board of directors. Doctor Everitt was born April 14, 1900, in Baltimore, Md., and holds the degrees of electrical engineer (1922) from Cornell University, master of science (1926) from the University of Michigan, and doctor of philosophy (1933) from Ohio State University. After service in the United States Marine Corps, Doctor Everitt became an instructor at Cornell University in 1920. Then after a period, 1922–24, with the North Electric Manufacturing Company, Galion, Ohio, he returned to teaching as instructor at the University of Michigan, Ann Arbor. In 1926 he joined the faculty of the University of Ohio, Columbus, as assistant professor of electrical engineering, becoming associate professor in 1929, and professor in 1934. During the war years, from 1942 to 1946, he was director of operational research staff of the Chief Signal Officer of the United States Army, Washington, D. C. He was appointed professor and head of the electrical engineering department by the University of Illinois in 1944. In 1946 Doctor Everitt was appointed to the electronics committee of the Joint Research and Development Board. He is the author of "Communication Engineering" and coauthor and editor of "Fundamentals of Radio." Doctor Everitt was chairman of the AIEE Columbus Section for 1931–32 and secretary for 1933–34. He has served on the AIEE committees on education and communication and was chairman of the latter from 1937 to 1939. He was elected president of the Institute of Radio Engineers in 1945 and is also a member of the Acoustical Society of America and the American Society for Engineering Education. He is executive vice-president of the National Electronics Conference for 1947 and chairman of the International Meeting on Marine Aids to Navigation for 1947.

Alexander Crawford Monteith (A '25, M '40, F '45) manager of headquarters engineering departments, Westinghouse

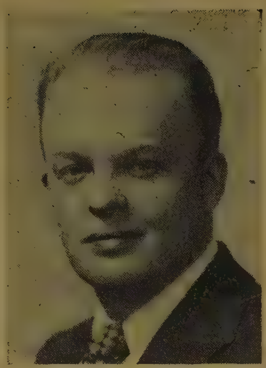
D. I. Cone

G. W. Bower

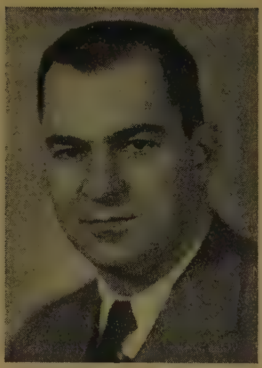
I. M. Ellestad

D. G. Geiger

W. L. Everitt



E. E. Grazda



A. C. Monteith

E. B. Robertson

Electric Corporation, East Pittsburgh, Pa., has been nominated for AIEE director. Born in Brucefield, Ontario, Canada, April 10, 1902, Mr. Monteith was graduated from Queens University in 1923. After completing the student course at the Westinghouse Corporation, he was assigned to the general engineering department in 1924. He was appointed manager of central station engineering in the industry engineering department in 1938 and manager of the department in 1941. He became director of education in 1945 and in addition was appointed manager of headquarters engineering departments in 1946. Exceptionally active in AIEE affairs, Mr. Monteith has served on the following committees: power generation, chairman 1942–44; protective devices; Standards, chairman 1944–45; planning and co-ordination; education; and Lamme Medal. He is secretary–treasurer of the AIEE Pittsburgh Section for 1946–47, and has represented the AIEE on committees of the American Standards Association and of the International Electrotechnical Commission. Mr. Monteith, who is author of many technical papers, received honorary mention for the best paper in engineering practice in the 1937 AIEE prize awards. He also is a member of the American Society of Mechanical Engineers, the Engineers Society of Western Pennsylvania, the International Conference on Large High-Voltage Electric Systems, and the American Society for Engineering Education, and he has served on committees of the National Electrical Manufacturers Association.

Elgin Barnett Robertson (M '24, F '45) president, Plastics Manufacturing Company, Dallas, Tex., has been nominated for AIEE director. Born June 4, 1893, in Meridian, Tex., Mr. Robertson was graduated from the University of Texas in 1915. He was with the Westinghouse Electric Corporation from 1915 to 1920 as student engineer and design engineer. He became chief electrical engineer for the Railway and Industrial Engineering Company, Greensburg, Pa., in 1920 and was transferred to Chicago, Ill., as district manager in 1924. In 1928 Mr. Robertson established the Elgin B. Robertson Company in Dallas, Tex., and since has been managing partner. When the Plastics Manufacturing Company was formed in 1939, he was made president. He joined the regional War Production Board as production engineer in 1942 and later was named regional utility engineer and regional manager of the production department. He was AIEE Section secretary in 1937 and chairman in 1938. He has served as vice-chairman of the AIEE membership committee and currently is serving on the committees on planning and co-ordination and registration of engineers.

Edward Emil Grazda (A '42) formerly design test engineer, Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., has joined the AIEE publications staff in New York, N. Y., as associate editor. Mr. Grazda was born September 2, 1915, in New York, N. Y., and was graduated from New York University with the degree of bachelor of science in electrical engineering in 1942. He was assistant editor of *Electronics*, New York, in 1941 and 1942 and was also junior engineer with Lincoln Walsh, Consulting Engineer, New York, in 1942. He joined the Minneapolis-Honeywell Company in 1943 as domestic field engineer and in 1944 was named senior field engineer. As such he was senior technical representative on the 20th Bomber Command's *B-29* project in India and China. He instructed army personnel in the theory, operation, and maintenance of electronic flight and turbosupercharger controls; supervised the design and construction of test equipment and depot repair facilities; and acted as consultant to the Army Air Forces. He also instructed maintenance personnel of the Central African Wing of the Air Transport Command and assisted in preparing a postwar training program while on Okinawa. He was appointed design test engineer in 1945. Mr. Grazda is a member of the Institute of Radio Engineers and Eta Kappa Nu.

William Kelly (F '25) chairman of the executive committee of the Buffalo (N. Y.) Niagara Electric Corporation, has retired from that position and is now chief of the Public Utilities Section, Industrial Branch, of the Office of Military Government, Berlin, Germany. Colonel Kelly was born in New York, N. Y., in 1877, attended Yale University, and was graduated from the United States Military Academy in 1899. For a number of years he was engaged in the construction of fortifications in San Francisco, Calif.; the Philippine Islands; and Long Island Sound, N. Y. He was engineer at Fort Leavenworth, Kans., and San Francisco from 1904 to 1906 and was in charge of the Water, Sewer, Building, and Electrical Department of Washington, D. C., from 1906 to 1910. He was again in the Philippines from 1910 to 1913 and was assistant to the chief of engineers in Washington from 1913 to 1917. During World War I he was chief engineer of the 42d Division and of the Fourth Army Corps and Deputy Chief of Staff. From 1917 to 1920 he was an assistant to the American Peace Commission. When the Federal Water Power Commission was organized in 1920, he was chosen chief engineer. He became vice-president of the Buffalo Niagara Corporation in 1926 and president and director in 1933. He received both the Legion of Honor decoration from the French Government and the Distinguished Service Medal of the United States in 1918. He is a member of the American Society of Mechanical Engineers, the American Association for the Advancement of Science, and the American Society of Civil Engineers.

H. L. Curtis (A '21, F '26) physicist and chief of the Interior Ballistics Section, National Bureau of Standards, Washington, D. C., has retired. Doctor Curtis received from the University of Michigan the degrees of bachelor of philosophy in 1900, master of arts in 1903, and doctor of philosophy in 1910. He was assistant professor at Michigan State College, East Lansing, from 1903 to 1907, the year he joined the National Bureau of Standards. He was made chairman of the committee that established accredited postgraduate courses at the bureau in 1908 and became chief of the Inductance Capacitance Section in 1915, and of the Interior Ballistics Section in 1946. His major achievement has been in the field of absolute electrical measurements. He has written a textbook on the subject, and his conclusions will form the basis for United States proposals in establishing a fixed relationship between the absolute and international electrical measurement units at the next International

Electrical Congress. He was made an honorary member of Phi Beta Kappa in 1940 and is a member of the American Association for the Advancement of Science, the American Physical Society, and the American Society for Testing Materials. He has been chairman of the committee on electrical insulating materials of the American Standards Association since 1934.

W. C. Smith (A '07, F '40) Pacific district engineer for the General Electric Company, San Francisco, Calif., and currently an AIEE director, has retired. Born in Michigan in 1882, Mr. Smith was graduated from the University of Michigan in 1905 and entered the testing department of the General Electric Company, Schenectady, N. Y. He was transferred to the transformer engineering department in 1907 as assistant designer and to the department in Pittsfield, Mass., as chief designer of reactors and railway compensators in 1908. In 1910 he was made assistant engineer in the distribution transformer engineering department, and in 1912 executive assistant to the chief engineer. He did special investigation work for the transformer engineering department at the Denver, Colo., office from 1918 to 1920 and in 1920 was named transformer specialist for the San Francisco office of the company. He was appointed assistant engineer of that office in 1931 and chief engineer in 1932. Mr. Smith received the Coffin Award of the company in 1925 "for ingenious design of combined transformer and autotransformer." He is a past chairman of the Pittsfield and San Francisco Sections of the AIEE and served as AIEE vice-president from 1941 to 1943.

J. T. Butterfield (A '10) engineer, Bell Telephone Laboratories, Inc., New York, N. Y., has retired. Mr. Butterfield holds the degrees of bachelor of science (1907) from Worcester Polytechnic Institute and electrical engineer (1910) from Purdue University. He entered the employ of the Bell System in 1910 to work on the development of an improved insulator for open-wire lines and then on the development of the magnetic structure of the 54-type retardation coil. He performed some of the early research work on magnetic materials. During World War I he supervised the development of switchboard lamps, vacuum thermocouples, and vacuum fuses and contributed to range-finding apparatus developments. He has been concerned with the development of electrolytic capacitors, studies of bearings and lubrication, and the development of improved methods of maintenance for base metals used in the panel system. Mr. Butterfield is responsible for the invention and development of the flexible multiple brush which is standard equipment for alleviating contact noise in panel systems.

A. B. Cooper (M '16, F '33) president and general manager, Ferranti Electric, Ltd., Toronto, Ontario, Canada, has retired from the position of general manager. He had been general manager since 1922. **J. M. Thomson** (A '26, M '30) formerly chief engineer of the company, succeeds Mr. Cooper as general manager. A graduate of the University of Toronto, Doctor Thomson also holds the degrees of master of science (1933) and doctor of philosophy (1937) from that university. After a year with the General Electric Company, Schenectady, N. Y., he joined the English Electric Company, St. Catharines, Ontario. His first position with Ferranti was that of radio engineer in 1926, and he became chief engineer in 1937. In 1930 he spent nine months in England in connection with the development of the surge absorber. He was chairman of the AIEE Toronto Section in 1940 and AIEE vice-president for District 10 for 1939–41.

R. D. Parker (A '07, M '14) telegraph development director, Bell Telephone Laboratories, Inc., New York, N. Y., has retired from that position and been appointed chief, Research Branch, Civil Communications Section, Tokyo, Japan, by the War Department. Mr. Parker received the degrees of bachelor of science in 1905 and master of science in 1906 from the University of Michigan. He became an instructor at the university in Ann Arbor and in 1909 was named assistant professor. He joined the American Telephone and Telegraph Company, New York, in 1913 to investigate special telegraph problems and soon after, when telegraph applications were initiated by the Bell System, was placed in charge of the telegraph equipment group. He later was concerned with the development of metallic telegraphy for cables, the first commercial application of which was on the New York–Philadelphia cable, and had a part in obtaining more telegraph channels from telephone circuits. When the development and research department of the company was merged with Bell Laboratories in 1934, he was placed in charge of the telegraph facilities department and was made telegraph development director in 1940.

C. S. Roys (M '45) formerly professor of electrical engineering and graduate supervisor, Illinois Institute of Technology, Chicago, has joined the faculty of Syracuse (N. Y.) University. Doctor Roys was graduated from Worcester Polytechnic Institute in 1923 and received the degree of master of science in 1929 and doctor of philosophy in 1933 from Purdue University. His teaching experience prior to his joining the Illinois Institute of Technology in 1942 had included instructorships at Purdue University, Lafayette, Ind., and at Union College, Schenectady, N. Y. His associations in industry have included positions with the General Electric Company, Schenectady; RCA Radiotron, Harrison, N. J.; and Continental Electrical Company, Geneva, Ill. Doctor Roys has been active in electronics and communications courses in the Signal Corps and Engineering, Science, and Management War Training programs.

J. H. Miller (A '19, F '42) chief engineer Weston Electrical Instrument Company, Newark, N. J., also has been appointed vice-president of the company. Mr. Miller was graduated from the University of Illinois in 1915 and was associated with the Westinghouse Electric Corporation, East Pittsburgh, Pa., from 1915 to 1918. During World War I he held a commission in the United States Signal Corps, and afterwards joined the Jewell Electrical Instrument Company, Chicago, Ill., as chief engineer. In 1927 he was made vice-president as well. When the company was merged with the Weston Company in 1931, Mr. Miller became assistant chief engineer at Newark, N. J. In 1937 he took charge of the commercial engineering division and in 1944 was appointed chief engineer. He is a member of the Institute of Radio Engineers and the Radio Club of America. He holds a number of patents in the United States, Great Britain, and Canada.

Glen Ireland (M '31) formerly property and costs engineer, American Telephone and Telegraph Company, New York, N. Y., has been elected a vice-president of the Pacific Telephone and Telegraph Company, San Francisco, Calif. After being graduated from the University of Iowa in 1917, he served overseas in World War I and in 1920 joined the Northwestern Bell Telephone Company, Des Moines, Iowa. In 1922 he was made division engineer and in 1923 was transferred to the operations and engineering department of the American Company. He was placed in charge of the equipment maintenance group in 1938 and named transmission engineer in 1939. He became operating results engineer in 1940 and property and costs engineer in 1946. He is a member of Tau Beta Pi and Sigma Xi.

W. F. Westendorp (A '35, M '43) research engineer, research laboratory, General Electric Company, Schenectady, N. Y., recently received the honorary degree of doctor of engineering from Rensselaer Polytechnic Institute. The citation recognizing Mr. Westendorp's achievements read in part: "He designed the resonance transformer which has made possible one- and two-million-volt X-ray units. . . He contributed greatly to the design and development of iron magnetic circuits and associated electronic circuits used in the construction of betatrons, particularly in the development of General Electric's 100,000,000-volt betatron. . . More recent improvements, designed and developed by him, have raised its energy output to 165,000,000 volts. . ." Born in Holland in 1905, Mr. Westendorp is a graduate of the University of Delft.

Chester Peterson (A '36) formerly chie engineer, Continental Electric Company, Inc., Newark, N. J., has been appointed physicist in the resistance measurements section of the National Bureau of Standards,

Washington, D. C. A 1926 graduate of Massachusetts Institute of Technology, Mr. Peterson was instructor at the institute in Cambridge, Mass., until in 1929 he was appointed to the Resistance Measurements Section of the Bureau of Standards. In 1933 he was transferred to the Naval Engineering Experimental Station, Annapolis, Md., and in 1935 he joined the engineering staff of H. A. Wilson Company, Newark. He entered the United States Army in 1942 and was assigned to the Evans Signal Laboratory, Belmar, N. J., and later to the Philadelphia (Pa.) Signal Corps Procurement District.

F. E. Harrell (A '26, F '40) formerly general works manager and a director of the Reliance Electric and Engineering Company, Cleveland, Ohio, has been elected manufacturing vice-president of the company. Mr. Harrell joined the company after he was graduated from Purdue University in 1924. He was made assistant chief engineer in 1934, served as executive director of the company's marine division plant during the early part of the war, became chief engineer in 1943, and general works manager in 1945. He is a member of the American Society of Naval Engineers and the Cleveland Engineering Society.

F. M. Clark (A '24) insulation expert at the Pittsfield (Mass.) works of the General Electric Company and assistant engineer of the works laboratory, has been named technical consultant on insulation of the entire apparatus department. Mr. Clark holds the degrees of bachelor and master of science from Wesleyan University. He has been engaged in insulation research and development work since he joined the company in 1923. He holds almost 100 patents in the field of insulation and has published numerous articles on the subject.

J. J. Wild (A '43) formerly project manager, electronics department, General Electric Company, Schenectady, N. Y., has been appointed sales manager of the Potter Instrument Company, Flushing, N. Y. Mr. Wild was graduated from Georgia Institute of Technology in 1942, at which time he joined the General Electric Company.

C. M. Fulk (A '16) electrical engineer in the central station engineering department, General Electric Company, Schenectady, N. Y., has retired. Mr. Fulk joined the company in 1907 after his graduation from Purdue University. He was engineer in the New York, N. Y., district from 1917 to 1922 and in 1922 was transferred to the central station division of the company.

D. G. Fink (M '45) editor of *Electronics*, New York, N. Y., has been elected a member of the board of the McGraw-Hill Pubing Company, Inc., New York.

R. E. McCoy (A '39) formerly technical assistant to section engineer, Signal Corps Engineering Laboratory, Camp Evans, N. J., has opened a consulting engineering office in Gresham, Oreg. Mr. McCoy, who was graduated from Oregon Institute of Technology in 1937, was associated with the Northwestern Electric Company, Portland, Oreg., until 1942. Shortly after entering the United States Army in 1942, he was assigned to the Signal Corps General Development Laboratory, predecessor of the SCEL, Eatontown, N. J. He later was transferred to Camp Evans. He is a member of the Institute of Radio Engineers.

R. W. Braswell (M '43) formerly assistant to the chief engineer, Louisiana Power and Light Company, New Orleans, now is operating superintendent of the Mississippi Power and Light Company. Mr. Braswell joined the Louisiana Company at West Monroe, La., in 1926 and was appointed division engineer in 1930. In 1940 he became assistant to the chief engineer.

R. M. Heintz (M '40) vice-president in charge of engineering, Jack and Heintz Precision Industries, Inc., Cleveland, Ohio, in addition temporarily will supervise production. Mr. Heintz was graduated from Leland Stanford University in 1920 and, after a period with the Standard Oil Company of California, formed several independent business enterprises. The Jack and Heintz Company was organized in 1940.

R. B. Le Vino (A '39) chief of the station equipment section, Signal Corps Engineering Laboratories, Fort Monmouth, N. J., recently was awarded the Meritorious Civilian Service Award by the War Department for "outstanding performance of assigned tasks and for initiative in developing, improving, and facilitating the production of printing telegraph equipment."

L. M. Klauber (A '11, F '23) formerly vice-president and general manager, San Diego (Calif.) Gas and Electric Company, has been elected president of the company. Mr. Klauber, who was graduated from Stanford University in 1908, completed a graduate apprenticeship course with the Westinghouse Electric Corporation before becoming salesman for the San Diego Company in 1911. He became superintendent of the electric department in 1914, assistant general superintendent in 1918, and general superintendent in 1920. In 1932 he was elected vice-president in charge of operation and, in 1941, vice-president and general manager.

A. C. Bredahl (M '44) formerly technical director of the better homes department, Westinghouse Electric Corporation, Pittsburgh, Pa., has been appointed manager of the department. Born in Denmark in 1899, Mr. Bredahl studied at Columbia University and the Polytechnic Institute in Oslo. He was chief of the mechanical-electrical utilities division of the Federal Public Housing Authority, Washington, D. C., from 1934 to 1943.

T. G. Barton (A '12, F '30) commercial vice-president, General Electric Company, New York, N. Y., has relinquished his duties as manager of the apparatus department for the New York district of the company. Mr. Barton will devote full time to his duties as a member of the staff of the president of the company.

G. W. Searle (A '42) formerly of the outside plant section of the operation and engineering department, American Telephone and Telegraph Company, New York, N. Y., has been transferred to the Wisconsin Telephone Company, Milwaukee, as transmission engineer in the engineering department.

E. A. Harty (A '22, M '36) section engineer on metallic rectifiers, General Electric Company, Lynn, Mass., has received a Charles Coffin Award of the company for his wartime development work on metallic rectifiers as applied to Army and Navy ordnance devices. Mr. Harty is secretary of the AIEE subcommittee on metallic rectifiers.

J. B. Fountain (A '35) formerly assistant general superintendent, operations and engineering department, Mississippi Power and Light Company, Jackson, has been appointed engineering superintendent of the company. A graduate of Mississippi State College, Mr. Fountain has been with the company since 1928.

L. M. Lyons (A '40) formerly field engineer, Burndy Engineering Company, New York, N. Y., has been made supervisor of the company's new factory and warehouse in Vernon, Calif. Mr. Lyons, a graduate of Massachusetts Institute of Technology, has been with the company since 1942.

A. F. Hartung (A '28, M '35) associate engineer, Burns and McDonnell Engineering Company, Kansas City, Mo., has been made a member of the firm. Mr. Hartung, a graduate of the University of Kansas, has been with the firm since 1929. Previously he had been associated with the General Electric Company, Philadelphia, Pa.

E. C. Ryan (A '36, M '44) formerly chief inspector, Ohio Brass Company, Mansfield, has been made chief manufacturing engineer of the Mansfield plant. Mr. Ryan joined the company as development engineer in 1935, after his graduation from the University of California.

W. L. Heard (A '26) systems staff engineer, Bell Telephone Laboratories, Inc., New York, N. Y., has been appointed to serve as technical observer to the United States National Committee of the International Electrotechnical Commission.

H. M. Schmitt (A '32) formerly engineer Brown Instrument Company, Philadelphia, Pa., has been named chemical industry manager of the company. He has been with the company since 1925.

J. M. Fluke (A '37) formerly commander, United States Naval Reserve, Arlington, Va., is now with the Anderson-Fluke Engineering Company, Springdale, Conn.

B. M. Jones (A '20, F '42) planning engineer, planning and development department, Duquesne Light Company, Pittsburgh, Pa., recently was appointed chairman of the engineering section of the Pennsylvania Electric Association for the 2-year term, 1946–1948.

N. B. Ames (A '20, M '26) professor and head of the electrical engineering department, George Washington University, Washington, D. C., has been elected vice-president of Theta Tau, national engineering fraternity.

J. W. Barker (M '26, F '30) president, Research Corporation, New York, N. Y., has been elected a trustee of the Illuminating Engineering Society Research Fund.

OBITUARY ● ● ● ●

Henry Hobart Porter (A '96, M '12) chairman of the board of the American Water Works and Electric Corporation, New York, N. Y., and director in many corporations died February 9, 1947. Mr. Porter, who was born March 12, 1865, in New York, was descended from John Porter who settled in America in the 17th century. He received the degree of mining engineer from Columbia University in 1886 and was associated with the Westinghouse Electric Corporation until 1896 as engineer and salesman. In 1896 he founded the well-known consulting engineering firm of Sanderson and Porter, New York. He retired from active partnership in 1941. The engineering firm was one of the earliest designers and constructors of oil pipe lines in mid-continent and California fields and made the first survey of the feasibility and economy of transporting gasoline long distances by pipe lines. Mr. Porter was responsible for one of the first 110-kv transmissions in the United States, which was installed for the United Railways of San Francisco, Calif. During World War I he supervised the planning and construction at Springdale, Pa., of one of the first large mine-mouth power generating stations. He was president of the American Water Works Company, which he saved from bankruptcy, from 1914 until at his own request he became chairman of the board in 1937. Among other foundering utility companies which Mr. Porter salvaged were the Brooklyn City Railroad and the surface lines of the Brooklyn Rapid Transit Company. He was chairman of the board of the West Penn Electric Company and a director of the Brooklyn Manhattan Transit Corporation, the Brooklyn and Queens Transit Corporation, the Chemical Bank and Trust Company, the Hudson and Manhattan Railroad, the McLellan Stores Company, the Tobacco Products Corporation of Delaware and New Jersey, and the United Stores Corporation. He had been a life trustee of Columbia University since 1938. He was a member of the executive committee of the National Research Council in 1925 and 1926, a member of the division of engineering and industrial research of that organization from 1924 through 1926, and chairman of the Engineering Foundation from 1929 through 1932. He held the honorary degrees of doctor of laws from Hobart College and doctor of engineering from Rensselaer Polytechnic Institute. He was a member of the board of managers and the finance committee of the New York Botanical Gardens and the board of trustees of the Edison Electric Institute. He also was a member of the American Society of Civil Engineers and the American Institute of Mining and Metallurgical Engineers.

William Lincoln Smith (M '22, F '40) professor emeritus, Northeastern University, Boston, Mass., died February 21, 1947, in Concord, Mass. Professor Smith had been head of the department of electrical engineering until his retirement in 1937. A descendant of the General Lincoln to whom General Cornwallis surrendered at Yorktown, he was born September 2, 1867, in Concord, Mass., received his secondary education at the Boston Latin School, and was graduated in 1890 from Massachusetts Institute of Technology. He then spent a year in Europe, studying at the University of Paris. He was appointed assistant in the department of physics at Massachusetts Institute of Technology, Cambridge, in 1890 and in 1892 was named instructor. He resigned in 1901 and went into consulting engineering work, specializing in illumination development. When a number of prominent educators started evening courses for adults, in 1896, Professor Smith was asked to organize the electrical courses of the Co-operative School of Engineering of the Young Men's Christian Association, which next became an evening school of engineering at Northeastern University. This developed into a full-fledged department of electrical engineering at the university in 1917, and Professor Smith was made head of the department. At his retirement in 1937 he received the honorary degree of doctor of engineering and the Boston Chamber of Commerce arranged a testimonial dinner in his honor. In keeping with the Concord tradition that citizens with special skills should serve the town, Professor Smith had held the post of inspector of wires since 1905 at the nominal salary of $50 per year. He was an associate trustee of the Underwriters Laboratory and a member of the National and International Associations of Electrical Inspectors, the English Society of Psychical Research, and the American Society for Engineering Education.

Otto Albrecht Knopp (A '09, M '34) retired head of the bureau of tests and inspection, Pacific Gas and Electric Company, Oakland, Calif., died December 19, 1946. Born in Berlin, Germany, August 24, 1877, Mr. Knopp received the degree of electrical engineer in 1899 from the University of Charlottenburg of Cothen. For a time he was test engineer with the Bergmann Electrical Works and assistant engineer with the aeronautical department of the Royal Prussian Meteorological Observatory, both in Berlin. In 1901 he became assistant engineer with the Blue Hill Observatory, Boston, Mass., and shortly afterwards joined the General Electric Company, Schenectady, N. Y. He joined the Oakland Gas, Light and Heat Company, San Francisco, in 1903 as assistant superintendent, and, when the company became the Pacific Company in 1908, he was named superintendent of the meter and test department. He was appointed head of the bureau in 1920. Mr. Knopp retired in 1942. He was consulting engineer and director of the Gardner Electric Manufacturing Company and of the Electrical Facilities, Inc. He had more than 40 patents to his credit and was a member of the Pacific Coast Electrical Association and the Engineers Club of San Francisco.

J. Leo Scanlon (A '28, M '34) president of the J. Leo Scanlon Electrical Equipment Company, Buffalo, N. Y., the Iowa Water Service Company, Iowa City, and the Missouri Service Company, Tarkio, died January 20, 1947. Mr. Scanlon was born October 31, 1891, in Iowa City and was graduated from the University of Iowa in 1914, receiving the degree of electrical engineer in 1919. He served in the air service of the United States Army in World War I and afterwards joined the Moloney Electric Company, St. Louis, Mo., as salesman, later becoming sales manager. In 1921 he went to Buffalo and in 1923 founded the Scanlon Electrical Company. In 1942 he acquired controlling interest in the Iowa Water Service Company, and in 1945 he purchased all the outstanding securities of the Missouri Service Company. He was a member of the Association of Iron and Steel Engineers and the New York State Society of Professional Engineers.

John James Little (A '22, M '34) vice-president and general manager, Northern British Columbia Power Company, Ltd., Prince Rupert, Canada, died December 26, 1946. Mr. Little was born in Edinburgh, Scotland, August 27, 1888. He served an apprenticeship with the McEwen Clarke and Company motor works in Edinburgh from 1903 to 1909 and, after a short period with the Tanfield Shipbuilding Company, moved to Canada in 1910. At first he was employed with various contractors and in 1912 became an electrician for the City of Prince Rupert. He served in the Imperial Forces from 1915 to 1919 and in 1921 was appointed assistant superintendent by the city of Prince Rupert, becoming superintendent in 1925. In 1929 he was made general manager of the Northern British Columbia Company. In 1945 he was named vice-president as well. Mr. Little was a member of the Association of Professional Engineers of British Columbia.

MEMBERSHIP . . .

Recommended for Transfer

The board of examiners, at its meeting of February 20, 1947, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the secretary of the Institute.

To Grade of Fellow

Goldsmith, L. M., ch. eng. Atlantic Refining Co., Philadelphia, Pa.
Holtz, F. C., vice-pres., & ch. eng., Sangamo Elec. Co., Springfield, Ill.
Lakin, C. E., pres., Buckeye Lt. & Pr. Co., & ten associated companies, Greenville, Ohio.
Kimbrell, M. R., elec. eng., Duke Pr. Co., Charlotte, N. C.
MacLean, J. B., elec. eng., power station consultant, Burns & Roe, Inc., New York, N. Y.
Scott, C. F., asst. to works mgr., General Elec. Co., Bridgeport, Conn.
6 to grade of Fellow

To Grade of Member

Allebaugh, R. O., field eng., Line Material Co., Washington, D. C.
Bates, E. J., asst. plant eng., National Cash Register Co., Dayton, Ohio.
Bean, C. L., elec. designer, engg. dept., E. I. duPont de Nemours & Co., Wilmington, Del.
Beardsley, K. D., dev. dist. transfer engg. div., General Elec. Co., Pittsfield, Mass.
Blackhall, J. P. M., development eng., North Elec. Mfgr. Co., Galion, Ohio.
Brown, W. H., mgr., Duke Pr. Co., Shelby, N. C.
Callender, E. M., elec. eng., The Budd Co., Philadelphia, Pa.
Charp, S., research assoc. in elec. engg., (project engineer), Univ. of Pennsylvania, Philadelphia, Pa.
Cooper, G. W., quality control eng., Line Material Co., Zanesville, Ohio.
Cowles, L. G., dev. & design eng., Superior Oil Co., Geophysical Lab., Houston, Tex.
Doll, E. B., ch. eng., North American Philips Co., Inc., Dobbs Ferry, N. Y.
Ellithorn, H. E., assoc. prof. elec. engg., Univ. of Notre Dame, Notre Dame, Ind.
Flowers, H. L., associate section head, Naval Research Lab., Washington, D. C.
Forster, A. G., elec. tech. asst. to planning officer, U. S. Navy, San Francisco, Calif.
Fransioli, W. J., Jr., asst. underground eng., Memphis Lt., Gas & Water Div., Memphis, Tenn.
Halpert, P., flight control research eng., Sperry Gyroscope Co., Inc., Great Neck, N. Y.
Hang, D. F., product eng., General Elec. Co., Schenectady, N. Y.
Hill, R. C., elec. eng., Robbins & Myers, Inc., Springfield, Ohio.
Hobbs, G. P., elec. eng., Bowater's Nfld. Pulp & Paper Mills, Corner Brook, Newfoundland.
Jackson, B. A., eng., Eastern div., H. H. Buggie & Co., New York, N. Y.
Jones, R. D., section eng., General Elec. Co., Fort Wayne, Ind.
Keck, M. W., sr. asst. relay eng., Toledo Edison Co., Toledo, Ohio.
Kraus, C. R., engineer-radio, Bell Tel. Co. of Pa., Philadelphia, Pa.
Kurriss, F. J., equip. eng., New York Tel. Co., New York, N. Y.
Larsen, T., assoc. prof. of elec. engg., Johns Hopkins Univ., Baltimore, Md.
Leftwich, M. F., elec. maintenance eng., Duke Pr. Co., Charlotte, N. C.
Lindheimer, E. M., elec. squad boss, The Lummus Co., New York, N. Y.
Lindsay, N. W., supt. of operations dept., Westchester Lighting Co., Mt. Vernon, N. Y.
MacDonald, M. W., consulting eng., 217 E. John St., Martinsburg, W. Va.
McConnell, J. D., plant eng., Proximity Mfgr. Co., Greensboro, N. C.
McFarland, J. L., transmitter supervisor, Radio Station *WMIT*, Marion, N. C.
Null, F. E., elec. eng., TSEPE-11 D, A.M.C., Wright Field, Ohio.
Olson, R. H., vice-pres., Elec. Machinery Mfgr. Co., Minneapolis, Minn.
Park, J. H., physicist, National Bureau of Standards, Washington, D. C.
Phillips, F. L., elec. eng., Kansas City Pr. & Lt. Co., Kansas City, Mo.
Potter, J. L., chairman, dept. of elec. engg., Rutgers Univ., New Brunswick, N. J.
Poulsen, G. G., dev. eng., General Elec. Co., Pittsfield, Mass.
Sherer, C. M., asst. chief of tests, Pennsylvania Water & Pr. Co., Holtwood, Pa.
Turner, D. W., ch. eng., Petroleum Rectifying Co., Houston, Tex.
VanTassell, W. H., outside plant eng., Westchester Lighting Co., & Yonkers Elec. Lt. & Pr. Co., Mount Vernon, N. Y.
Werner, D. T., district mgr., Anaconda Wire & Cable Co., Charlotte, N. C.
Williams, L. F., asst. elec. eng., Southern Pacific Co., San Francisco, Calif.
42 to grade of Member.

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before April 21, 1947, or June 21, 1947, if the applicant resides outside of the United States or Canada.

To Grade of Fellow

Williams, R. C. G., North American Philips Co., Inc., New York, N. Y.
1 to grade of Fellow

To Grade of Member

Bagley, G. J., General Motors Corp., Detroit, Mich.
Balleny, J. L., Canadian General Elec. Co. Ltd., Toronto, Ontario, Canada.
Barnhill, C. V., U. S. Coast Guard, Washington, D. C.
Blair, N. W., Lindberg Engg. Co., Chicago, Ill.
Bolen, J. C., John Bolen & Co., Charlotte, N. C.
Bricout, P. E., Laval University, Quebec, Quebec, Canada.
Callanan, J. A., Illinois Tool Works, Chicago, Ill.
Calvert, R. L., British Thomson-Houston Co., Ltd., Rugby, England.
Cirella, L. E., Simplex Wire & Cable Co., Cambridge, Mass.
Clarke, W. R., Jr., Square D Co., Cincinnati, Ohio.
Deist, J. W., Wisconsin Tel. Co., Milwaukee, Wis.
Froehlich, C., City College, New York, N. Y.
Gerlach, W. G., General Elec. Co., Toledo, Ohio.
Gerst, P. E., Paul E. Gerst & Co., Chicago, Ill.
Ghose, R. S. S. C., Patna Elec. Supply Co. Ltd., Patna, Bihar, India.
Hawkins, J. E., Seismograph Service Corp., Tulsa, Okla.
Hayes, R. A. H., H. G. Acres & Co., Niagara Falls, Ontario, Canada.
Henry, W. E., Jr., National Elec. Products Corp., Charlotte, N. C.
Hill, C. C., American Enka Corp., Enka, N. C.
Johnson, C. F., Jr., The Bristol Co., Waterbury, Conn.
Kerr, G. W., War Dept., Corps of Engrs., Portland, Oreg.
Lavingia, J. P., Tarun Elec. Industries, Ahmedabad, India.
LeSage, C. W., Western Elec. Co., Inc., Chicago, Ill.
MacDonald, W. A., Canadian Line Materials, Ltd., Toronto, Ontario, Canada.
McDaniel, J. D., War Assets Administration, Seattle, Wash.
Mehring, J. S., Western Elec. Co., Inc., New York, N. Y.
Neiswinter, J. T., American Tel. & Tel. Co., New York, N. Y.
Pancoast, H. R., Bryant Elec. Co., Inc., High Point, N. C.
Partos, G., Colourfast Ltd., London, England.
Payne, A. G., Monsanto Chemical Co., Springfield, Mass.
Pernice, J. R., Naval Ordnance Lab., Washington, D. C.
Peterson, R. W., Northern States Power Co., Minneapolis, Minn.
Radt, M., City College, New York, N. Y.
Rouse, A. F., Consolidated Edison Co. of N. Y., Inc., New York, N. Y.
Sack, F. A., Solar Aircraft Corp., San Diego, Calif.
Sims, F., Govt. of Bihar, Patna, Bihar, India.
Sloan, F. H., R. H. Bouligny, Inc., Charlotte, N. C.
Smeby, R. P., Commonwealth Edison Co., Chicago, Ill.
Spicer, A. D., Kewanee Boiler Corp., Kewanee, Ill.
Sterman, J. W., The Lummus Co., New York, N. Y.
Stevens, D. L., N. Y. Tel. Co., New York, N. Y.
Stromberg, S. E., N. Y. Tel. Co., New York, N. Y.
Swan, W. V., Nantahala Pr. & Lt. Co., Franklin, N. C.
Teacherson, A. G., Commonwealth Edison Co., Chicago, Ill.
Thomas, R. N., General Elec. Co., Schenectady, N. Y.
Vandenberg, J., American Enka Corp., Enka, N. C.
Wahlquist, K. D., Dow Chemical Co., Houston, Tex.
Weeks, H. V., Sr., H. V. Weeks, Inc., Kearny, N. J.
Weiss, E. L., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
Wilkinson, W. C., The Rowan Controller Co., Baltimore, Md.
Williamson, W. O., Tennessee Valley Authority, Chattanooga, Tenn.
51 to grade of Member

To Grade of Associate

United States, Canada and Mexico

1. North Eastern

Allen, J. S., General Elec. Co., Pittsfield, Mass.
Anderson, A. W., General Elec. Co., Schenectady, N. Y.
Anderson, R. M., General Elec. Co., Lynn, Mass.
Angell, J. B., Massachusetts Inst. of Tech., Cambridge, Mass.
Auer, G. G., General Elec. Co., Schenectady, N. Y.
Bachtel, W. C., General Elec. Co., Schenectady, N. Y.
Beaman, A. L., Jr., Westinghouse Elec. Corp., Buffalo, N. Y.
Becker, H. J., Jr., Warsaw Elevator Co., Warsaw, N. Y.
Bickerstaff, R. P., Blackstone Valley Gas & Elec. Co., Woonsocket, R. I.
Bixby, W. L., Tufts College, Medford, Mass.
Bloodworth, W. H., General Elec. Co., Schenectady, N. Y.
Boon, J. A., IBM Corp., Endicott, N. Y.
Bradbeer, B. H., General Elec. Co., Lynn, Mass.
Brant, H. A., General Elec. Co., Schenectady, N. Y.
Brennan, R. H., General Elec. Co., Pittsfield, Mass.
Brody, A. L., 22 Fairbanks St., Brookline, Mass.
Bryant, D. M., General Elec. Co., Schenectady, N. Y.
Bryant, N. H., Cornell Univ., Ithaca, N. Y.
Buckingham, R. P., General Elec. Co., Schenectady, N. Y.
Burton, W. E., General Elec. Co., Schenectady, N. Y.
Canfield, E. B., General Elec. Co., West Lynn, Mass.
Chapman, C. B., Hartford Elec. Lt. Co., Hartford, Conn.
Chatterton, J. B., Chance Vought Aircraft, Stratford, Conn.
Clark, A. H., Smith Technical High, Syracuse, N. Y.
Clark, F. M., General Elec. Co., Schenectady, N. Y.
Christopher, A. A., Jr., General Elec. Co., Schenectady, N. Y.
Countryman, C. (re-election) General Elec. Co., Schenectady, N. Y.
Da Silva, H. C., General Elec. Co., Schenectady, N. Y.
Dean, F. P., General Elec. Co., Schenectady, N. Y.
DeVore, R. W., General Elec. Co., Schenectady, N. Y.
Dickerson, A. F., General Elec. Co., Schenectady, N. Y.
Dilts, I. J., Jr., General Elec. Co., Lynn, Mass.
Donley, R. M., Cambridge Field Station, Cambridge, Mass.
Dow, H. E., Univ. of Maine, Orono, Maine.
Driesch, T. W., General Elec. Co., Schenectady, N. Y.
Drozin, J. S., Westinghouse Elec. Corp., Buffalo, N. Y.
Dunaiski, R. M., General Elec. Co., Schenectady, N. Y.
Elliott, L., General Elec. Co., Schenectady, N. Y.
Erhart, F. C., General Elec. Co., Schenectady, N. Y.
Fagrelius, C. A., General Elec. Co., Schenectady, N. Y.
Fiantaca, J. S., Stone & Webster Engg. Corp., Boston, Mass.
Forbes, W., General Elec. Co., Lynn, Mass.
Fox, E. J., General Elec. Co., Schenectady, N. Y.
Fredricksen, J. J., General Elec. Co., Schenectady, N. Y.
Fritz, R. J., General Elec. Co., Schenectady, N. Y.
Gilligan, S. R., Jr., Harvey-Wells Electronics, Inc., Southbridge, Mass.
Gisser, D. G., Rensselaer Poly. Inst., Troy, N. Y.
Goodman, R. J., Sr., General Elec. Co., Schenectady, N. Y.
Gridley, P. A., Ensign, USNR, 127 Madison Ave., Holyoke, Mass.
Grondalski, S. J., New England Tel. & Tel., Lowell, Mass.
Gustafson, R. W., General Elec. Co., Schenectady, N. Y.
Halfhill, D. W., General Elec. Co., Lynn, Mass.
Hall, H. S., North American Philips Co., Inc., Lewiston, Maine.
Harney, J. M., General Elec. Co., Schenectady, N. Y.
Hart, C. B., Allis-Chalmers Mfg. Co., Boston, Mass.
Hart, C. H., III, Raytheon Mfg. Co., Waltham, Mass.
Henry, W. S. C., New England Pr. Service Co., Providence, R. I.
Hershberger, D. D., General Elec. Co., Schenectady, N. Y.
Hickcox, R. J., Jr., General Elec. Co., Schenectady, N. Y.
Hom, R. N. G., P. O. Box 223, Boston, Mass.
Hoo, G. J. S., Hixon Elec. Co., Boston, Mass.
Hughes, E. S., Jr., IBM Corp., Endicott, N. Y.
Hurley, R. B., General Elec. Co., Schenectady, N. Y.
Hussey, C. M., Yale School of Law, New Haven, Conn.
Hutchinson, R. E., General Elec. Co., Schenectady, N. Y.
James, J. Z., New England Pr. Assn., Boston, Mass.
Jennings, C. E. (re-election) General Elec. Co., Schenectady, N. Y.
Johnson, M. R., General Elec. Co., Pittsfield, Mass.
Johnson, R. S., N. Y. State Elec. & Gas Corp., Binghamton, N. Y.
Johnston, D. L., General Elec. Co., Pittsfield, Mass.
Jones, J. T., General Elec. Co., Pittsfield, Mass.
Klotz, H. J., IBM Corp., Endicott, N. Y.
Knapp, R. T., New York Tel. Co., Albany, N. Y.
Knight, R. H., Narragansett Elec. Co., Providence, R. I.
Knox, D. W., General Elec. Co., Schenectady, N. Y.
Landis, N. W., Allis-Chalmers Mfg. Co., Syracuse, N. Y.

Large, W. E., Westinghouse Elec. Corp., Cheektowaga, N. Y.
Lebel, C. M. A., Massachusetts Inst. of Tech., Cambridge, Mass.
Lehr, C. G., Massachusetts Inst. of Tech., Cambridge, Mass.
Levine, A. B., General Elec. Co., Pittsfield, Mass.
Looser, J. C., Scoville Mfg. Co., Waterbury, Conn.
MacAllister, T. C., Jr., Southern New England Tel. Co., New Haven, Conn.
MacDonald, L. A., American District Teleg. Co., New York, N. Y.
Mackeown, R. C., Syracuse Univ., Syracuse, N. Y.
Magnuson, J. E., General Elec. Co., Lynn, Mass.
Mahoney, T. F., Massachusetts Inst. of Tech., Cambridge, Mass.
Marin, I. L., General Elec. Co., Schenectady, N. Y.
McNamee, F. G., Jr., General Elec. Co., Lynn, Mass.
Mickelsen, J. K., General Elec. Co., Schenectady, N. Y.
Miller, A. N., IBM Corp., Endicott, N. Y.
Nye, J. R., General Elec. Co., Pittsfield, Mass.
Olney, C. H., Eastman Kodak Co., Rochester, N. Y.
Orlando, A. J., Rensselaer Poly. Inst., Troy, N. Y.
Owens, O. G. (re-election) Union College, Schenectady, N. Y.
Palakowski, A. J., General Elec. Co., Schenectady, N. Y.
Palmer, J. R., General Elec. Co., Schenectady, N. Y.
Patterson, N. J., Jr., General Elec. Co., Schenectady, N. Y.
Patton, P. W., Cambridge Field Station, A.M.C., Cambridge, Mass.
Peacock, H. L., General Elec. Co., Schenectady, N. Y.
Petitjean, R. J., General Elec. Co., Schenectady, N. Y.
Place, J. F., General Elec. Co., Syracuse, N. Y.
Porter, R. G., New England Tel. & Tel. Co., Boston, Mass.
Pratt, F. L., IBM Corp., Endicott, N. Y.
Przybyla, A., New Bedford Gas & Edison Lt. Co., New Bedford, Mass.
Randall, J. L., General Elec. Co., Schenectady, N. Y.
Schaible, E. F., General Elec. Co., Pittsfield, Mass.
Sencay, J. F., cadet, U. S. Army, West Point, N. Y.
Sidebottom, J. K., General Elec. Co., Schenectady, N. Y.
Sindelar, F. J., IBM Corp., Endicott, N. Y.
Smith, D. H., General Elec. Co., Pittsfield, Mass.
Smith, J. F., General Elec. Co., Schenectady, N. Y.
Smith, W. W., General Elec. Co., Schenectady, N. Y.
Sofen, I. A., Bell Aircraft Corp., Buffalo, N. Y.
Sorauf, J. G., General Elec. Co., Schenectady, N. Y.
Spencer, R. H., Univ. of Connecticut, Storrs, Conn.
Sperlin, R. B., General Elec. Co., Schenectady, N. Y.
Stahl, H. G., General Elec. Co., West Lynn, Mass.
Stein, J. M., Westinghouse Elec. Corp., Buffalo, N. Y.
Stempnitzky, I., Massachusetts Inst. of Tech., Cambridge, Mass.
Stickler, S. V., Jr., Westinghouse Elec. Corp., Buffalo, N. Y.
Striker, R. G., 58 South Drive, Plandome, N. Y.
Stroble, R. L., General Elec. Co., Schenectady, N. Y.
Strode, V. C., Jr., General Elec. Co., Schenectady, N. Y.
Subach, A., Jr., Lawrence Gas & Elec. Co., Lawrence, Mass.
Sullivan, J. J., IBM Corp., Endicott, N. Y.
Sutter, R. P., General Elec. Co., Syracuse, N. Y.
Sweeney, J. I., General Elec. Co., Syracuse, N. Y.
Sydor, T. J., General Elec. Co., Schenectady, N. Y.
Tuteur, F. B., Raytheon Mfg. Co., Waltham, Mass.
Watt, G. W., Univ. of Buffalo, Buffalo, N. Y.
Wilkins, H. A., Brown Univ., Providence, R. I.
Wolff, G. M., General Elec. Co., Syracuse, N. Y.
Wooding, E. R., IBM Corp., Endicott, N. Y.
Wright, C., Jr., General Elec. Co., Syracuse, N. Y.
Zangari, L. A. J., New England Pr. Service Co., Worcester, Mass.

2. Middle Eastern

Adams, R. F., Villanova College, Villanova, Pa.
Allen, B. F., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Amchin, H. K., Atlantic City Elec. Co., Atlantic City, N. J.
Appleman, C. B., Naval Mine Warfare Test Station, Solomons, Md.
Balderston, G., Jr., Philadelphia Elec. Co., Philadelphia, Pa.
Barnes, J. C., Weber Dental Mfg. Co., Canton, Ohio.
Bartlett, D. H., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Battaglia, D. A., Drexel Technological Inst., Philadelphia, Pa.
Baxter, J. L., Univ. of Maryland, College Park, Md.
Bergquist, K. G., Keller-Pike Co., Philadelphia, Pa.
Binder, D., Franklin Inst. of State of Pennsylvania, Philadelphia, Pa.
Birx, D. L., The Johns Hopkins Univ., Baltimore, Md.
Bodker, J. R., Jr., Jack & Heintz Precision Ind., Inc., Bedford, Ohio.
Bronson, R. W., American Sterilizer Co., Erie, Pa.
Brophy, J. E., Naval Research Lab., Washington, D. C.
Brown, M. K., Sunray Electric, Inc., Warren, Pa.
Burdick, A. S., Ohio Pr. Company, Canton, Ohio.
Burns, R., I-T-E Circuit Breaker Co., Philadelphia, Pa.
Calmer, D. E., General Elec. Co., Cleveland, Ohio.
Carlisle, B. H., Jr., Clark Controller Co., Cleveland, Ohio.
Cheppa, E., 418 Centre Street, Freeland, Pa.
Connelly, J. B., Sperry Gyroscope Co., Inc., Baltimore, Md.
Craig, P. M., U. S. Patent Office, Dept. of Commerce, Washington, D. C.
Cronshey, R. W., The Radiart Corp., Cleveland, Ohio.
Davis, J. F., General Elec. Co., Erie, Pa.
DeRemer, K. R., RCA Labs., Princeton, N. J.
Diamond, J. M., Bendix Radio Corp., Baltimore, Md.
Donahoe, E. J., Delaware Pr. & Lt. Co., Wilmington, Del.
Donaldson, W. A., Jr., Westinghouse Elec. Co., Swissvale, Pa.
Dorratcague, P. E., Glenn L. Martin Aircraft Co., Baltimore, Md.
Ebisch, R. P., General Elec. Co., Erie, Pa.
Eggimann, E. L., Leland Elec. Co., Dayton, Ohio.
Eliason, J. R., General Elec. Co., Baltimore, Md.
Emerson, E. W., Chesapeake & Potomac Tel. Co., Washington, D. C.
Emerson, R. L., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Evans, V. R., Consolidated Gas, Elec. Lt. & Pr. Co., Baltimore, Md.
Feitler, J., General Chemical Co., Naaman, Del.
Ford, B. H., Jr., U. S. Army, Wright Field, Dayton, Ohio.
Fountain, R. E., General Elec. Co., Erie, Pa.
French, C. G., Union Switch & Signal Co., Pittsburgh, Pa.
Frick, A. E., Diebold, Inc., Canton, Ohio.
Gaskill, W. A., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Genger, P. T., Packard Elec. Div., GMC, Warren, Ohio.
Gerngross, J. J., The Philadelphia Elec. Co., Philadelphia, Pa.
Gilson, R. A., Solar Elec. Corp., Warren, Pa.
Gisburne, E. H., Budd Co., Philadelphia, Pa.
Gossick, B. R., RCA, Victor Div., Camden, N. J.
Grauling, C. H., Jr., Johns Hopkins Univ., Baltimore, Md.
Grim, C. L., Cons. Gas, Elec. Lt. & Pr. Co. of Baltimore, Baltimore, Md.
Greenleaf, F. D., RCA, Victor Div., Camden, N. J.
Gurney, B., Fenn College, Cleveland, Ohio.
Hamilton, L. F., Jr., Philadelphia Elec. Co., Philadelphia, Pa.
Harding, G. R., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Hart, J. E., Naval Research Lab., Washington, D. C.
Hayman, J. L., Baldwin Locomotive Works, Eddystone, Pa.
Heck, R. C., Elliott Co., Philadelphia, Pa.
Hedding, F. R., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Henrichs, E. F., Westinghouse Elec. Corp., Baltimore, Md.
Hess, S. R., RCA, Victor Div., Lancaster, Pa.
Himmel, R. N., RCA, Victor Div., Camden, N. J.
Holland, D. R., Consolidated Gas & Elec. Co., Baltimore, Md.
Horelick, A. L., Pennsylvania Transformer Co., Canonsburg, Pa.
Hultzman, W. W., Brush Development Co., Cleveland, Ohio.
Hunt, W. T., Jr., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Huyett, W. I., Reading Co., Reading, Pa.
James, P. M., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
Jewett, G. W., Lt., U. S. Naval Academy, Annapolis, Md.
Johnson, C. Y., Naval Research Lab., Washington, D. C.
Johnson, W. N., Westinghouse Elec. Corp., Pittsburgh, Pa.
Johnston, R. F., Carbide & Carbon Chem. Corp., So. Charleston, W. Va.
Joseph, W. T., 534 So. River St., Wilkes-Barre, Pa.
Kaplan, M. N., Drexel Institute, Philadelphia, Pa.
Katz, L. L., B. F. Goodrich Co., Akron, Ohio.
Keith, R. H., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Kratzer, J. L. E., Lehigh Portland Cement Co., Allentown, Pa.
Lambert, H. R., Westinghouse Elec. Corp., Baltimore, Md.
Lammers, V. H., Cincinnati Gas & Elec. Co., Cincinnati, Ohio.
Landis, C. G., Safe Harbor Water Pr. Corp., Conestoga, Pa.
Lawrence, R. J., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Lee, F. N., May & Bond, Washington, D. C.
LePere, D. G., Westinghouse Elec. Co., East Pittsburgh, Pa.
Loveman, B. D., Curtiss-Wright Corp., Columbus, Ohio.
Lucas, R. L., Univ. of Pittsburgh, University, Pa.
Lynch, C. R., Curtiss-Wright Corp., Columbus, Ohio.
MacDonald, E. H., Univ. of Pennsylvania, Philadelphia, Pa.
Marie, C. S., Westinghouse Elec. Corp., Baltimore, Md.
Marin, I., G., General Elec. Co., Erie, Pa.
Markling, J. C., General Elec. Co., Erie, Pa.
Martin, E. E., Cleveland Twist Drill Co., Cleveland, Ohio.
Matthews, E. W., Jr., Westinghouse Elec. Corp., East Pittsburgh, Pa.
McAdam, R. B., Westinghouse Elec. Corp., Wilkinsburg, Pa.
McCary, R. O., General Elec. Co., Erie, Pa.
McCubbin, A. J., Consolidated Gas Elec. Lt. & Pr. Co., Baltimore, Md.
McDonnold, R. O., Westinghouse Elec. Co., East Pittsburgh, Pa.
Means, T. T., General Elec. Co., Erie, Pa.
Mergner, G. C., Jr., Leeds & Northrup Co., Philadelphia, Pa.
Middendorf, W. H., The Aviation Corp., Cincinnati, Ohio.
Miller, M., Naval Ordnance Lab., Washington, D. C.
Milroy, F. P., Rev., Maryknoll College, Clarks Summit, Pa.
Mitchell, J. H., American Tel. & Tel. Co., Washington, D. C.
Murphy, J. M., R. A. Murphy Elec. Co., Washington, D. C.
Mussina, G. A., Gas & Elec. Co., Baltimore, Md.
Nelson, A. E., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Nitschke, N. E., Western Elec. Co., Allentown, Pa.
Nuce, H. R., Jr., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Nygren, R. T., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Obloy, S. J., Westinghouse Elec. Corp., Cleveland, Ohio.
Oren, J. D., Propeller Lab., Wright Field, Dayton, Ohio.
Paratore, J., Ohio Edison Co., Springfield, Ohio.
Patterson, J. W., Philadelphia Elec. Co., Philadelphia, Pa.
Peterson, E. F., Jr., Aero Service Corp., Philadelphia, Pa.
Pickard, R. W. (re-election) Union Metal Mfg. Co., Canton, Ohio.
Pida, G., Naval Research Lab., Washington, D. C.
Pimlott, J. R., David Taylor Model Basin, Washington, D. C.
Ramsey, R. B., Bell Tel. Labs., Baltimore, Md.
Raven, R. S., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Regnier, C., Rural Electrification Admn., Washington, D. C.
Ritchie, W. A., Naval Research Lab., Washington, D. C.
Roadstrum, W. H., U. S. Bureau of Mines, Pittsburgh, Pa.
Roberts, R. E., Sylvania Elec. Products Inc., Emporium, Pa.
Rohrer, R. E., Jansky & Bailey, Consulting Radio Engrs., Inc., Washington, D. C.
Saab, R. A., 354 Bouquet St., Pittsburgh, Pa.
Schadt, R., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Schmalz, R. V., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Shank, J. H., Univ. of Cincinnati, Cincinnati, Ohio.
Sidlo, T. C., General Elec. Co., Cleveland, Ohio.
Simmons, L. W., Commonwealth of Penna., Harrisburg, Pa.
Singer, G. A., Radio Corp. of America, Camden, N. J.
Skinner, R. L., Philco Radio & Television Corp., Phila., Pa.
Slaughter, L. S., Jr., Carbide & Carbon Chem. Corp., So. Charleston, W. Va.
Smith, D. J., General Elec. Co., Philadelphia, Pa.
Sommers, D. J., Westinghouse Elec. Corp., Pittsburgh, Pa.
Span, R. E., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Stevenson, F. R., Atlantic Refining Co., Philadelphia, Pa.
Strand, H. V., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Timken, H. A., Jr., The Kellex Corp., Silver Spring, Md.
Travis, R. I., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Trenner, J. F., Bethlehem Steel Co., Sparrows Pt., Md.
Trese, R. E., Univ. of Toledo, Toledo, Ohio.
Vrana, V. E., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Walter, R. E., Ohio Northern Univ., Ada, Ohio.
Ward, P. H., Ward Drug Store, Versailles, Ohio.
Warren, R. A., Westinghouse Elec. Corp., Akron, Ohio.
Welch, T. P., Philadelphia Elec. Co., Philadelphia, Pa.
Whitlatch, E., Jr., Dayton Pr. & Lt. Co., Dayton, Ohio.
Wilde, K. E., General Elec. Co., Philadelphia, Pa.
Wiley, J. G., General Elec. Co., Philadelphia, Pa.
Wilkins, J. H., 1611 Princess Ave., Pittsburgh, Pa.
Winkle, L., Curtiss-Wright Corp., Columbus, Ohio.
Winokur, P., Jr., NE Cor. 19th & Federal Sts., Philadelphia, Pa.

3. New York City

Andrews, R. C., Bakelite Corp., Bound Brook, N. J.
Atlas, H. T., Western Elec. Co., New York, N. Y.
Bacon, L. W., Western Union Tel. Co., New York, N. Y.
Beach, P. E., R. B. Dana Co., New York, N. Y.
Blachere, B., Hazeltine Electronics Corp., Little Neck, N. Y.
Blaustein, A., Sperry Gyroscope Co., Great Neck, N. Y.
Bokhari, I. A. S., 286—6th Ave., Brooklyn, N. Y.
Brill, D., General Elec. Supply Corp., New York, N. Y.
Campbell, C. R., General Elec. Co., New York, N. Y.
Cannon, W. W., Devenco, Inc., New York, N. Y.

Cassano, J. D., Sperry Gyroscope Co., Great Neck, N. Y.
Casazza, J. A., Public Service Elec. & Gas Co., Newark, N. J.
Chronister, I. G., USS *Sprig* (AM 384), c/o FPO, New York, N. Y.
Chu, G. Y., Westinghouse Elec. Corp., Newark, N. J.
Chu, J. K., National Resources Comm. of China, New York, N. Y.
Coben, M. S., Radio Receptor Co., Inc., New York, N. Y.
Davis, S., Liquidometer Co., New York, N. Y.
Deacy, J., 180 East 239th St., New York, N. Y.
Delzio, F. J., Board of Transportation, New York, N. Y.
Donahue, J. F., Jr., Westinghouse Elec. Corp., New York, N. Y.
Dressler, R., Paramount Pictures, Inc., New York, N. Y.
Fellner, R., Hazeltine Electronics Corp., Little Neck, N. Y.
Foster, E. L., A. H. Bull Steamship Line, New York, N. Y.
Frawley, J. E., Western Elec. Co., Kearny, N. J.
Fredericksen, L. H., Otis Elevator Co., New York, N. Y.
Friday, J. B., Jr., H. H. Roberts & Co., Inc., New York, N. Y.
Gausz, J. A. C., Western Elec. Co., Newark, N. J.
Gaynor, E., American District Teleg. Co., New York, N. Y.
Gigante, D. M., Consolidated Edison Co. of N. Y., Inc., New York, N. Y.
Goldstein, C., 570 West 193rd St., New York, N. Y.
Hannah, M. R., Sperry Gyroscope Co., Inc., Great Neck, N. Y.
Harper, H., Bell Tel. Labs., Inc., New York, N. Y.
Heine, T. H., Westinghouse Elec. Corp., Bloomfield, N. J.
Henley, E. M., Airborne Instruments Lab., Mineola, N. Y.
Heverly, L. F., (re-election), Ebasco Services, Inc., New York, N. Y.
Highfill, W. E., Standard Oil Development Co., Elizabeth, N. J.
Hoffman, S. D., Western Elec. Co., New York, N. Y.
Hubert, C., U. S. Merchant Marine Academy, Kings Point, N. Y.
Jones, C. R., Westinghouse Elec. Corp., Jersey City, N. J.
Kant, M., Reeves Inst. Corp., New York, N. Y.
Kende, J., Closure-Consultants & Designers, Inc., New York, N. Y.
Kotas, D. E., MacKay Radio & Tel. Co., New York, N. Y.
Kraus, R. I., McLaughlin-Carr Associates, New York, N. Y.
Kravetz, R., Board of Transportation, New York, N. Y.
Kunstadt, G. H., Western Elec. Co., Kearny, N. J.
Litsios, J., W. L. Maxson Corp., New York, N. Y.
Lovenstein, A. J., Fairchild Airplane & Engine Corp., Farmingdale, N. Y.
Maguire, J. A., Western Elec. Co., Kearny, N. J.
Markowitz, S., City College, New York, N. Y.
Martin, L. H., USN, USS *Franklin D. Roosevelt*, (CVB-42), FPO, New York, N. Y.
Mayhew, L. A., Ebasco Services, Inc., New York, N. Y.
McCarthy, E. F., Western Union Teleg. Co., New York, N. Y.
McEwan, A. W., RFD Boonton Ave., Butler, N. J.
McPhee, J. R., Jr., Underwriters Labs., New York, N. Y.
Meenagh, J. P., Cutler-Hammer, Inc., New York, N. Y.
Mogul, E., Commercial Cable Co., New York, N. Y.
Moldoff, S., Board of Transportation, New York, N. Y.
Morris, G. W., Curtis Elevator Co., Long Island City, N. Y.
Olszewski, W. T., Board of Transportation, New York, N. Y.
Osder, S. S., Western Elec. Co., Newark, N. J.
Papsco, W. G., Jr., Westinghouse Elec. Corp., Newark, N. J.
Pelliconi, R. R., American Locomotive Co., New York, N. Y.
Pope, M., Myers, Fuller & Addington, New York, N. Y.
Reymers, H. E., Raytheon Mfg. Co., New York, N. Y.
Robinson, F. B., Federal Tel. & Radio Corp., Newark, N. J.
Rockett, F. H., Jr., McGraw-Hill Publ. Co., New York, N. Y.
Rose, R. M., New Jersey Bell Tel. Co., Clifton, N. J.
Rosenberg, P. R., Arma Corp., Brooklyn, N. Y.
Salit, L., Atlantic N. Y. Corp., New York, N. Y.
Sarch, R., Electronic Associates, Inc., Long Branch, N. J.
Sauter, W. A., Federal Tel. & Radio Corp., Clifton, N. J.
Scharff, S. A., 285 Madison Ave., New York, N. Y.
Schoeffler, H. A., American Tel. & Tel. Co., New York, N. Y.
Seabrooke, J. P., N. Y. Tel. Co., Brooklyn, N. Y.
Sexauer, B. H., Ebasco Services Inc., New York, N. Y.
Shanley, W. C., General Elec. Co., Trenton, N. J.
Shapiro, L., Polytechnic Research & Development Co., Brooklyn, N. Y.
Smith, R. L., Jr., Long Island Lighting Co., Mineola, N. Y.
Smith, W. S., 66 Linden Ave., Verona, N. J.
Spellman, W. J., Public Service Elec. & Gas Co., Hackensack, N. J.
Stanton, I. B., Jr., Consolidated Edison Co. of N. Y., Inc., Long Island City, N. Y.
Stubbs, J. W., Chemical Construction Corp., New York, N. Y.
Swift, R. A., Bell Tel. Labs., New York, N. Y.
Ugelow, L., 1237—51st St., Brooklyn, N. Y.
Velleman, J. E., Metropolitan Life Ins. Co., Housing, New York, N. Y.
von Alt, A. J., Ebasco Services, Inc., New York, N. Y.
Walsh, C. E., John Mather Lupton Co., Inc., New York, N. Y.
Weber, L. A., Bell Tel. Labs., New York, N. Y.
Weigand, E. F., Western Elec. Co., Kearny, N. J.
Wengryn, M., Kollsman Instrument, Elmhurst, N. Y.
Winterroth, E. G., Morganite, Inc., Long Island City, N. Y.
Yennie, D. R., Stevens Inst. of Tech., Hoboken, N. J.
Zeller, J. F., Western Elec. Co., Inc., New York, N. Y.
Zadeh, L. A., Columbia Univ., New York, N. Y.
Zuckerbraun, J. S., 2260 Olinville Ave., New York, N. Y.
Zusselman, H. L., Cyclohm Motor Corp., Long Island City, N. Y.

4. Southern

Barrett, R. D., Memphis Light Gas & Water Div., Memphis, Tenn.
Barrow, J. W., Graybar Elec. Co., Richmond, Va.
Boyd, J. A., Univ. of Kentucky, Lexington, Ky.
Boyd, J. R., Southern Bell Tel. & Tel. Co., Louisville, Ky.
Busch, W. R., Knoxville Utilities Board, Knoxville, Tenn.
Butler, A. T., Tennessee Valley Authority, Chattanooga, Tenn.
Caplan, S., Atomic Energy Comm., Oak Ridge, Tenn.
Carlson, R. S., Mississippi State College, State College, Miss.
Crabtree, D., Dan River Mills, Inc., Danville, Va.
Daniel, J. N., Stone & Webster Corp., Norfolk, Va.
Davis, F. L., So. Bell Tel. & Tel. Co., Columbia, S. C.
Doescher, J. W. (Mrs.), 176 North Peterson, Louisville, Ky.
Earnhardt, L. P., Duke Pr. Co., High Point, N. C.
Estelle, W. E., North Carolina State College, Raleigh, N. C.
Evans, R. R., Jr., Kentucky & West Virginia Pr. Co., Ashland, Ky.
Farinholt, W. W., General Elec. Co., Atlanta, Ga.
Feller, C. E., NACA, Langley Field, Va.
Freeman, F. R., Stanolind Oil & Gas Co., Lake Charles, La.
Garrett, A. L., Jr., So. Bell Tel. & Tel. Co., Knoxville, Tenn.
Harward, H. B., Duke Pr. Co., Durham, N. C.
Hinson, R. B., c/o Pelzer Mills, Pelzer, S. C.
Hoffman, C. R., Southern Rwy. Co., Charlotte, N. C.
Kerby, W. D., Jr., Western Union Teleg. Co., Atlanta, Ga.
Kuehn, H. S., Naval Proving Ground, Dahlgren, Va.
Lichenstein, H. M., Electron Engg. Co., New Orleans, La.
McKee, J. C., Jr., Mississippi State College, State College, Miss.
Modlin, J. C., Duke Pr. Co., Durham, N. C.
Morgan, K. H., 1024 Wisteria Ct., Alexandria, La.
Rawls, L. E., WSM Transmitter, Franklin, Tenn.
Robinson, D., USN, Underwater Sound Reference Lab., Orlando, Fla.
Ross, K. E., Monsanto Chemical Co., Knoxville, Tenn.
Shultz, J. H., Louisville Radio School, Louisville, Ky.
Seay, W. R., Southern Bell Tel. & Tel. Co., Inc., New Orleans, La.
Walchli, H. E., Tennessee Eastman Corp., Knoxville, Tenn.
Watkins, W. B., American Printing House for the Blind, Louisville, Ky.

5. Great Lakes

Atkins, J. C., Jr., Cutler-Hammer, Inc., Milwaukee, Wis.
Barnes, P. O., General Elec. Co., Chicago, Ill.
Barnett, C. W., Hanover College, Hanover, Ind.
Bawtinheimer, C. E., Dow Chemical Co., Midland, Mich.
Bevis, J. H., Mich. Bell Tel. Co., Detroit, Mich.
Bischoff, B. G., Cardox Corp., Chicago, Ill.
Brenk, H. E., Brenk Elec. Equipment Co., Chicago, Ill.
Browne, P. J., (re-election), Commonwealth Edison Co., Chicago, Ill.
Burbach, W. P., Cutler-Hammer Inc., Milwaukee, Wis.
Bursh, T. W., Western Elec. Co., Cicero, Ill.
Capitolo, M. L., The Louis Allis Co., Milwaukee, Wis.
Casey, J. G., Commonwealth Edison Co., Chicago, Ill.
Christensen, L. W., Cutler-Hammer Inc., Milwaukee, Wis.
Clark, C. S., General Elec. Co., Chicago, Ill.
Cockrill, S. B. (re-election), Public Service Co. of No. Ill., Chicago, Ill.
Craft, C. J., III, Univ. of Michigan, Ann Arbor, Mich.
Craig, R. B., Illinois Bell Tel. Co., Chicago, Ill.
Criss, D. E., Rose Polytechnic Inst., Terre Haute, Ind.
Crothers, J. M., A. T. & S. F. Ry. Co., Chicago, Ill.
Eagan, W. F., Allis-Chalmers Mfg. Co., West Allis, Wis.
Erickson, R. S., Engineering Research Associates, St. Paul, Minn.
Ervin, L. H., 373 Farrington St., St. Paul, Minn.
Evans, L. E., Standard Oil Co., Whiting, Ind.
Featherstone, R. P., H-T Electronics Labs., Inc., Minneapolis, Minn.
Fee, W. F., Western United Gas & Elec. Co., Aurora, Ill.
Fisher, G. F., Stanley Engineering Co., Muscatine, Iowa
Fox, J. R., Public Service Co. of No. Ill., Glencoe, Ill.
Frohmberg, C. R., Univ. of Michigan, Ypsilanti, Mich.
Garton, H. L., Commonwealth Edison Co., Chicago, Ill.
Gilman, D. W., Commonwealth Edison Co., Chicago, Ill.
Gokbudak, M. T., 509 South Davison, Ann Arbor, Mich.
Grant, J. E., Westinghouse Elec. Corp., Chicago, Ill.
Hallberg, L. K., General Elec. X-Ray Corp., Milwaukee, Wis.
Halvorson, J. A., Cutler-Hammer, Inc., Milwaukee, Wis.
Hansen, P., Commonwealth Edison Co., Chicago, Ill.
Hawkins, T. K., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Hedges, M. C., Commonwealth Edison Co., Chicago, Ill.
Heitshu, G. D., Chicago Elec. Co., Chicago, Ill.
Hendricks, W. W., Hendricks Elec. Co., Peoria, Ill.
Hennekes, P. J., Shell Oil Co., Wood River, Ill.
Herrick, H. F., Louis Allis Co. Elec. Motors, Milwaukee, Wis.
Hiller, J. H., Western Elec. Co., St. Paul, Minn.
Hodgman, A. J., W. A. Jackson Co., Chicago, Ill.
Hollowell, J. A., General Elec. Co., Fort Wayne, Ind.
Houlton, R. L., Elk River, Minn.
Humke, F. O., Jr., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Jensen, J. L., Fairbanks, Morse & Co., Beloit, Wis.
Johnson, M. E., Furnas Elec. Co., Batavia, Ill.
Johnston, E. R., Westinghouse Elec. Supply Co., St. Paul, Minn.
Johnston, R. J., Jr., Consumers Pr. Co., Flint, Mich.
Jordan, H. E., Manufacturers Battery Co., Madison, Wis.
Kandlik, C. G., Western Elec. Co., Chicago, Ill.
Keen, M. B., Aluminum Ore Co., East St. Louis, Ill.
Kennedy, W. J. L., Standard Oil Co., Whiting, Ind.
Kerney, R. W., Republic Flow Meters Co., Chicago, Ill.
Kihm, J., Allen-Bradley Co., Milwaukee, Wis.
Koenig, E. A., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Koerber, R. J., Michigan Bell Tel. Co., Detroit, Mich.
Kull, F. J., Dow Chemical Co., Midland, Mich.
Lauber, T. S., Commonwealth & Southern Corp., Jackson, Mich.
Leive, E. W., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Lockwood, N. E., Illinois Northern Utilities Co., Dixon, Ill.
Lopez C., R., Allis-Chalmers Mfg. Co., W. Allis, Wis.
Lux, F. E., Northern Indiana Pub. Service Co., Hammond, Ind.
MacFarlane, R. S., Chicago Dist. Elect. Gen. Corp., Hammond, Ind.
Maegaard, R. T., Dynamatic Corp., Kenosha, Wis.
Makowski, J. J., Milwaukee Vocational School, Milwaukee, Wis.
McStay, F. W., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Mehring, R. C., Wisconsin Elec. Pr. Co., Milwaukee, Wis.
Mitchell, M. W., Commonwealth Edison Co., Chicago, Ill.
Myers, H. A., I. T. & T., Lansing, Mich.
Nelson, R. E., John Dolio, Chicago, Ill.
Neuenfeldt, D. K., Kimberly-Clark Corp., Neenah, Wis.
Orthel, J. C., Northwest Airlines, Minneapolis, Minn.
Oura, K., Kyle Corp., S. Milwaukee, Wis.
Paap, P., Consumers Pr. Co., Grand Rapids, Mich.
Podl, M. J., Commonwealth Edison Co., Chicago, Ill.
Pollard, O. W., Central Illinois Elec. & Gas Co., Rockford, Ill.
Potesky, T., Dooley-St. Arnaud Elec. Co., Chicago, Ill.
Rech, R. H., U. S. Fidelity and Guaranty Co., Chicago, Ill.
Russell, L. H., Square D Co., Milwaukee, Wis.
Saline, L. E., Univ. of Wisconsin, Madison, Wis.
Schlie, R. W., Jefferson Elec. Co., Bellwood, Ill.
Schrader, F. S., Western Elec. Corp., Cicero, Ill.
Schrieber, W. F., Louis Allis Co., Milwaukee, Wis.
Senello, J. J., Continental Can Co., Chicago, Ill.
Stahmann, J. R., Lightning & Transients Research Inst., Minneapolis, Minn.
Steffen, C. L., Bucyrus-Erie, Co., S. Milwaukee, Wis.
Stelk, L. R., (re-election), Commonwealth Edison Co., Chicago, Ill.
Story, K. J., (re-election), Commonwealth Edison Co., Chicago, Ill.
Stuart, B. S., Parke, Davis & Co., Detroit, Mich.
Summers, K. D., Allen-Bradley Co., Milwaukee, Wis.
Swanstrom, W. M., Campbell Soup Co., Chicago, Ill.
Sylvan, I. S., Graybar Elec. Co., Chicago, Ill.
Taggart, D. K., Consumers Pr. Co., Jackson, Mich.
Tapley, T. E., Univ. of Michigan, Ann Arbor, Mich.
Tepper, L. E., Sargent & Lundy, Chicago, Ill.
Toht, A. E., Western Elec. Co., Hawthorne, Ill.

Trierweiler, L. G., Western United Gas & Elec Co., Aurora, Ill.
Unnewehr, L. E., Northern Indiana Pub. Service Co., Hammond, Ind.
Vavra, H. G., Westinghouse Elec. Supply Co., St. Paul, Minn.
Veline, R. A., Iowa State College, Ames, Iowa.
Wanzek, P. J., Univ. of Wisconsin, Madison, Wis.
Warner, R. C., Allis-Chalmers Mfg. Co., Chicago, Ill.
Weise, F. F., Shell Oil Co., Inc., Wood River, Ill.
Westermeyer, J., Western Elec. Co., Cicero, Ill.
Whitney, M. J., Louis Allis Co., Milwaukee, Wis.
Wilcox, D. D., Jr., Purdue Univ., W. Lafayette, Ind.
Wilts, J. R., Iowa State College, Ames, Iowa.
Wuebben, A. J., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Zaburunov, A. S., Univ. of Michigan, Ann Arbor, Mich.
Zechel, L. A., Allis-Chalmers Mfg. Co., Milwaukee, Wis.

6. North Central

Allen, C. N., Allis-Chalmers Mfg. Co., Omaha, Nebr.
Clark, D. E., Univ. of Colorado, Boulder, Colo.
Corliss, W. M., Bureau of Reclamation, Denver, Colo.
Davis, W. L., Hathaway Instrument Co., Denver, Colo.
Hanna, W. J., Univ. of Colorado, Boulder, Colo.
Hupp, C. E., Bureau of Reclamation, Denver, Colo.
Isaak, R. D., Univ. of Colorado, Boulder, Colo.
Jones, R. A., Pub. Service Co. of Colorado, Denver, Colo.
Lanham, L. E., Bureau of Reclamation, Denver, Colo.
Noland, J. W., Electronic Radio & Television Inst., Omaha, Nebr.

7. South West

Aguilar S., L. H., Cia Nacional de Electricidad, Torreon, Coah., Mexico.
Andrews, W. A., Black & Veatch, Kansas City, Mo.
Blankenship, W. B., 2701—21st St., Lubbock, Tex.
Botkin, C. C., New Mexico A. & M., State College, N. M.
Brock, F. A., Geophysical Service, Inc., Dallas, Tex.
Cantrell, F. W., Southwestern Bell Tel. Co., El Reno, Okla.
Castillo B., M., (re-election), General Elec. S A, Mexico, Federal District, Mexico.
Clarke, C. J., Humble Pipe Line Co., Ingleside, Tex.
Cuadriello, I., Fabrica de Papel de Coyoacan, Coyoacan, Federal District, Mexico.
Dague, W. L., Jr., A. B. Chance Co., Centralia, Mo.
Davis, J. R., Baker Engg. Inc., San Antonio, Tex.
Desmond, D. M., A. & M. College of Tex., College Station, Tex.
Duncan, J. M., Southwestern Pub. Service Co., Amarillo, Tex.
Evers, E. P. (re-election), Wagner Elec. Corp., St. Louis, Mo.
Farmer, J. L., Oklahoma Gas & Elec. Co., Okla. City, Okla.
Fuchs, A. R., City Pr. Plant, Lubbock, Tex.
Furtney, H. M., Paul Berry, Mfgr. Agent, Tulsa, Okla.
Gaddy, J. L., Jr., Moloney Elec. Co., St. Louis, Mo.
Guymon, V. F., Otis Elevator Co., Dallas, Tex.
Harman, D. G., Atlantic Refining Co., Andrews, Tex.
Hatfield, R. L., A. B. Chance Co., Centralia, Mo.
Heizer, L. O., Dallas Pr. & Lt. Co., Dallas, Tex.
Henke, C. R., Dallas Pr. & Lt. Co., Dallas, Tex.
Hiltpold, L. E., Humble Pipeline Co., Ingleside, Tex.
Hodgson, D. L., McDonnell Aircraft Corp., St. Louis, Mo.
Horton, J. B., Greenville, Tex.
Hunt, G. O., Jr., Dow Chemical Co., Freeport, Tex.
Ingram, C., Jr., A & M College of Tex., College Station, Tex.
Jackson, C. R., Houston Lighting & Pr. Co., Houston, Tex.
Jerkins, J. T., 1800 Euclid, Oklahoma City, Okla.
Keys, R. T., Jr., Seismograph Service Corp., Tulsa, Okla.
Lucky, G. W., Southwestern Bell Tel. Co., Dallas, Tex.
Lanfare, J., National Biscuit Co., Houston, Tex.
Luhnow, R. B., Jr., Burns & McDonnell Engg. Co., Kansas City, Mo.
Martyn, J. L., W. P. Martyn, Mech. Contr., Dallas, Tex.
Maul, D. T., White Rodgers Elec. Co., St. Louis, Mo.
Meletio, J. T., Meletio Elec. Supply Co., Dallas, Tex.
Mollenhauer, A. A., City Pub. Service Bd., San Antonio, Tex.
Nichols, D. C., Southwestern Bell Tel. Co., Oklahoma City, Okla.
Randle, L. V., Saxet Co., Inc., Dallas, Tex.
Rann, J. A., Jr., Seismograph Service Corp., Walters, Okla.
Riese, R. L., New Mexico State College of A. & M., State College, N. Mex.
Ruiz, R. H., Industria Nacional De Medallas, San Alvaro, Ats, Federal District, Mexico.
Schneider, R. H., Westinghouse Elec. Corp., St., Louis, Mo.
Sessel, R., Southwest Engineers, Dallas, Tex.
Sites, G. A., Southwestern Bell Tel. Co., St. Joseph, Mo.
Smith, M. G., Western Union Teleg. Co., Dallas, Tex.
Stewart, C. A., Kansas Pr. & Lt. Co., Manhattan, Kans.
Turner, R. D., Kansas City Pr. & Lt. Co., Kansas City, Mo.
Valcik, J. H., Shell Chemical Corp., Houston, Tex.
Weiss, O. W., James R. Kearney Corp., St. Louis, Mo.
Welch, H. R., Dow Chemical Co., Freeport, Tex.

8. Pacific

Brolin, E. G., Standard Oil Co. of Calif., San Francisco, Calif.
Burt, W. F., USS *Doran* (DMX-41), Pascresflt, San Diego, Calif.
Burt, W. T., Ensign, USN, USS *AFD1 34*, cxo FPO San Francisco, Calif.
Caustin, E. L., North American Aviation, Inc., Los Angeles, Calif.
Carver, C. R., ensign, USNR, USS *General G. M. Randall* AP, cxo FPO, San Francisco, Calif.
Clanton, R. O., USCE, Manila Engr. Dist., APO, c/o PM, San Francisco, Calif.
Creswell, J. C., Bechtel Corp., Los Angeles, Calif.
Cronin, W. F., General Elec. Co., Los Angeles, Calif.
Crooks, J. W., Jr., Consolidated Vultee Aircraft Corp., San Diego, Calif.
DeLano, R. H., Hughes Aircraft Co., Culver City, Calif.
Diamond, P., Stone & Webster Engg. Corp., Los Angeles, Calif.
Doeleman, H., 3125 Kelburn Ave., Garvey, Calif.
Doran, J. J., Jr., Bureau of Engg., City Hall, San Francisco, Calif.
Earl, G. C., C. F. Braun & Co., Alhambra, Calif.
Fulton, E. L., Square D Co., San Diego, Calif.
Funke, F. E., Jr., Douglas Aircraft Co., Santa Monica, Calif.
Galvan, M. A. (Miss), Pacific Tel. & Tel. Co., San Francisco, Calif.
Gilbert, P. H., Southern California Edison Co., Ltd., Los Angeles, Calif.
Gillihan, M. E., Bureau of Pr. & Lt., Los Angeles, Calif.
Girouard, L. O., Jr., Southern California Tel. Co., Los Angeles, Calif.
Gockley, R., Southern California Edison Co., Los Angeles, Calif.
Greathouse, T. E., Pacific Tel. & Tel. Co., San Francisco, Calif.
Grondorf, C. A., Univ. of California, Berkeley, Calif.
Hargrove, H. L., Pacific Gas & Elec. Co., Oakland, Calif.
Holm, E. N. (re-election) Sacramento Municipal Utility District, Sacramento, Calif.
Hunter, A. R., Clyde A. Krasne Co., Los Angeles, Calif.
Huth, W. R., Northrop Aircraft Co., Hawthorne, Calif.
Jerome, M. G., Pacific Tel. & Tel. Co., San Francisco, Calif.
Johnson, R. D., General Elec. Supply Corp., San Francisco, Calif.
Jones, W. C. P., Southern California Tel. Co., Los Angeles, Calif.
Kness, B. P., General Elec. Co., San Francisco, Calif.
Knoyle, D. I., San Francisco Naval Shipyard, San Francisco, Calif.
LeSiege, A. J., Westinghouse Elec. Corp., Emeryville, Calif.
Looschen, F. W., Ames Aero Lab., NACA, Moffett Field, Calif.
Lyon, W. D., North American Aviation, Inc., Los Angeles, Calif.
Mathews, T. E., Jr., Southern California Tel. Co., Los Angeles, Calif.
Myers, W. A., North American Aviation, Inc., Inglewood, Calif.
Newcomer, P. E., ensign, USNR, c/o FPO, San Francisco, Calif.
Paulson, S. W., C. F. Braun & Co., Alhambra, Calif.
Quan, J., Pacific Gas & Elec. Co., San Francisco, Calif.
Rupel, L. D., 2254 Sixth St., La Verne, Calif.
Schlussel, A., Frederic Frisbie, Los Angeles, Calif.
Schmidt, S. F., NACA, Moffett Field, Calif.
Schrieber, O. W., U. S. Navy Electronics Lab., San Diego, Calif.
Sept, C. L., Philco Corp., APO 928, c/o PM, San Francisco, Calif.
Steidtmann, C. E., Jr., C. E. Steidtmann & Associates, Oakland, Calif.
Steinman, A. A., North American Aviation, Inc., Los Angeles, Calif.
Tiner, E. A., Pacific Gas & Elec. Co., San Francisco, Calif.
Turner, H. G., Pacific Tel. & Tel. Co., San Francisco, Calif.
Warshawsky, H., Dept. of Pub. Utilities & Transportation, Los Angeles, Calif.
Waters, J. M., ensign, Supply Corps, USNR, c/o FPO, San Francisco, Calif.
Weld, R. A., Southern California Tel. Co., Los Angeles, Calif.

9. North West

Allison, C. W., Jr., Puget Sound Pr. & Lt. Co., Seattle, Wash.
Angell, J. R., Permanente Metals Corp., Trentwood, Wash.
Beckner, B. E., Boeing Aircraft Co., Seattle, Wash.
Bourbonnais, T. L., II, Idaho Pr. Co., Boise, Idaho.
Clare, R. H., Portland General Elec. Co., Portland, Oreg.
Clayton, V. E., Radio Service Corp. of Utah, Salt Lake City, Utah.
Herman, R. H., Boeing Aircraft Co., Seattle, Wash.
Hoffman, J. D., Jr., General Elec. Co., Richland, Wash.
Holmes, R. L., Boeing Aircraft Co., Seattle, Wash.
Newman, S. O., Ames Aeronautical Lab., NACA, Moffett Field, Calif.
Norton, R. J., Puget Sound Pr. & Lt. Co., Olympia, Wash.
Olds, M. L., 2111 S. E. Madison, Portland, Oreg.
Ringlee, R. J., Univ. of Washington, Seattle, Wash.
Robinson, C. T., War Dept., Corps. of Engrs., Portland, Oreg.
Sanborn, R. A., Reynolds Metals Co., Troutdale, Oreg.
Smith, S. R., General Elec. Co., Richland, Wash.
Stephenson, R. E., Univ. of Utah, Salt Lake City, Utah.
Tomsic, E. M., ensign, USNR, Swan Island, Portland, Oreg.
Webb, H. C., Puget Sound Pr. & Lt. Co., Seattle, Wash.

10. Canada

Ascroft, G. C., Canadian Westinghouse Co., Hamilton, Ontario, Canada.
Auld, B. A., National Research Council, Ottawa, Ontario, Canada.
Bowles, G. W., Howard Smith Paper Mills, Ltd., Montreal, Quebec, Canada.
Carter, H. B., Bowater's Nfld. Pulp and Paper Mills, Ltd., Corner Brook, Newfoundland.
Clifton, W. L., Canadian General Elec. Co., Peterborough, Ontario, Canada.
de Launay, L. H. W., Bell Tel. Co. of Canada, Ottawa, Ontario, Canada.
Duncan, N. M., Bell Tel. Co., Toronto, Ontario, Canada.
Gerrie, D. J., Hydro-Elec. Pr. Comm., Toronto, Ontario, Canada.
Halischuk, E., Univ. of Toronto, Toronto, Ontario, Canada.
Hammerslag, J., Northern Elec. Co., Montreal, Quebec, Canada.
Hampton, S. J., Elec. Lt. & Pr. Distribution Dept., Edmonton, Alberta, Canada.
Herzog, G. W., Canadian General Elec. Co., Peterborough, Ontario, Canada.
Hopkins, C. H., Univ. of Toronto, Toronto, Ontario, Canada.
Kennedy, J. E., Canadian General Elec. Co., Peterborough, Ontario, Canada.
Kenny, W. E., B. C. Pr. Comm., Victoria, British Columbia, Canada.
Kozak, S., Univ. of Toronto, Toronto, Ontario, Canada.
Langdon, K. R. N., Hydro-Elec. Pr. Comm. of Ont., Toronto, Ontario, Canada.
MacDonald, D. L., Edmonton Transportation System, Edmonton, Alberta, Canada.
McAulay, D. R., 98 Cumberland St., Toronto, Ontario, Canada.
McGillivray, G. N., Corp. of the City of Hamilton, Hamilton, Ontario, Canada.
McMichael, W. G., B. C. Elec. Rwy. Co., Ltd., Abbotsford, British Columbia, Canada.
Meen, A. K., Ridout & Maybee, Toronto, Ontario, Canada.
Montalbetti, R., National Research Council, Ottawa, Ontario, Canada.
Nicholson, W. V., Consolidated Mining & Smelting Co. of Canada, Trail, British Columbia, Canada.
Posen, P., Univ. of Toronto, Toronto, Ontario, Canada.
Prevey, W. H., Canadian General Elec. Co., Toronto, Ontario, Canada.
Raynor, D. G., Bell Tel. Co. of Canada, Toronto, Ontario, Canada.
Silk, W. F., Univ. of Toronto, Toronto, Ontario, Canada.
Turner, K. A., Bell Tel. Co. of Canada, Toronto, Ontario, Canada.
Vergin, L. J., Aluminum Labs. Ltd., Montreal, Quebec, Canada.
Young, C. W., Aluminum Co. of Canada, Montreal, Quebec, Canada.

Elsewhere

Barnes, V. F. W., c/o N. Y. & Honduras Rosario Mining Co., San Juancito, Republica de Honduras, C. A.
Boton, M., Ankara taskeri faurikalar, Ankara, Turkey.
Carmichael, H. C., U. S. Information Service, Manila, P. I.
Cavill, R. T., Newton Bros. (Derby) Ltd., Derby, England.
Donaldson, G. H., III, CAA, Anchorage, Alaska.
Greene, E. E., CAA, Anchorage, Alaska.
Jones, L. R., U. S. Naval Operating Base, Dutch Harbor, Alaska.
Omar, Y. A., Ports & L'houses Administration, Alexandria, Egypt.
Pavlov, A. V., Shanghai Power Co., Shanghai, China.
Rivera, H. G., IBM Corp., San Juan, Puerto Rico.
Santanam, S., Electrical Services (Trichy) Ltd., Trichinopoly, India.
Seif El Din, O., Delta Motor Co., Cairo, Egypt.
Shaw, A. C., Bihar Govt., Bihar, India.
Siocos, C. A., Naval Radiotelegraphic Service, Ministry of Marine, Athens, Greece.
Tsao, H-C., Wahson Elec. Mfg. Co., Ltd., Shanghai, China.
Vega, H. R., Caonillas Project, Utuado, Puerto Rico.

Total to grade of Associate
United States, Canada and Mexico, 692
Elsewhere, 16

OF CURRENT INTEREST

Some 1946 Books for Electrical Engineers

The Engineering Societies Library has followed up its 1945 reading list for engineers (*EE, Mar '46, pp 139–40*) with a list of what it considers important books of interest to electrical engineers which have been published in 1946.

In compiling the list, the library staff allowed brevity rather than all-inclusiveness to dictate its choices. It carefully refrained from calling the list "best" books, pointing out that to a librarian the best book is the one that supplies the information the reader needs when he needs it, regardless of the general merit of the book.

ELECTRON MICROSCOPE. By E. F. Burton and W. H. Kohl. Second edition. Reinhold Publishing Corporation, New York, N. Y. $4.

PIEZOELECTRICITY. By W. G. Cady. McGraw-Hill Book Company, Inc., New York, N. Y., 1946. 806 pages, $9. The entire field is covered in this comprehensive treatise, including related areas of elasticity, dielectrics, optics, and magnetism.

ELECTRONICS IN INDUSTRY. By G. M. Chute. McGraw-Hill Book Company, Inc., New York, N. Y., 1946. 461 pages, $5. Industrial uses of tube circuits are outlined, and detailed explanation of a large number of electronic devices used in industrial plants is given.

RADAR. By O. E. Dunlap, Jr. Harper and Brothers, New York, N. Y., 208 pages, $2.50. Traces the history of radar from the early reflected wave experiments of Hertz and Marconi and presents a simple explanation of its basic features.

DIESEL-ELECTRIC LOCOMOTIVE. By C. F. Foell and M. E. Thompson. Diesel Publications, New York, N. Y., 1946. 688 pages, $7. Deals with the constructional, engineering, operational, and maintenance aspects of the subject. Also covers the history, development, advantages, and classification of Diesel-electric locomotives.

PULSED LINEAR NETWORKS. By E. Frank. McGraw-Hill Book Company, Inc., New York, N. Y., 1945. 267 pages, $3. Analyzes transients in mathematical terms that are familiar to most electrical engineers and engineering students in order to set the stage for a more advanced study of the subject.

INDUCTANCE CALCULATIONS, WORKING FORMULAS, AND TABLES. By F. W. Grover. D. Van Nostrand Company, Inc., New York, N. Y., 1946. 286 pages, $5.75. Prepared with the idea of providing for each special type of inductor a single simple formula that will involve only the parameters that naturally enter, together with numerical factors obtainable from tables.

QUARTZ CRYSTALS FOR ELECTRICAL CIRCUITS. By R. A. Heising. D. Van Nostrand Company, Inc., New York, N. Y., 1946. 563 pages, $6.50. Discusses the development of this application of quartz crystals, demonstrates methods for determining their desirable qualities, and describes the manufacturing and testing processes by which they are made effective for this purpose.

TELEVISION SIMPLIFIED. By M. S. Kiver. D. Van Nostrand Company, Inc., New York, N. Y., 1946. 375 pages, $4.75. Presents a complete, practical description of modern television in step-by-step fashion without involved theory or mathematics.

INDUCTION HEATING. By H. B. Osborn, Jr. American Society for Metals, Cleveland, Ohio, 1946. 172 pages, $3. Deals with the principles and theory of high frequency heating; induction heating circuits and frequency generation; practical applications of the motor generator type of induction heating (up to 10,000 cycles); practical applications of high frequency induction heating (100,000 cycles and up); a comparison of induction heating with other methods of heat treating.

FUNDAMENTAL THEORY OF SERVOMECHANISMS. By L. A. MacColl. D. Van Nostrand Company, Inc., New York, N. Y., 1945. 130 pages, $2.25. The main concern is with the general theory which is applicable to all linear continuously operating servomechanisms and their essential identity with feedback amplifiers. Although some particular servomechanisms are discussed for illustration, no attempt has been made to consider design details.

PERSONALITY AND ENGLISH IN TECHNICAL PERSONNEL. By P. B. McDonald. D. Van Nostrand Company, Inc., New York, N. Y., 1946. 424 pages, $3.75. Emphasizes the importance of developing a definite personality, an accurate command of English, and effective methods for presenting ideas, both written and verbal, with specific suggestions for improvement in these particulars.

LUMINOUS TUBE LIGHTING. By H. A. Miller. Chemical Publishing Company, Brooklyn, N. Y. 143 pages, $3.50. Underlying principles of the luminous tube are explained; materials and equipment involved in their manufacture are described; and discharge tube light sources are discussed.

ENGINEER IN SOCIETY. By John Mills. D. Van Nostrand Company, Inc., New York, N. Y. 196 pages, $2.50. A group of essays, dealing with the relationship of scientists and engineers to the world society in which they function.

CHRONOLOGICAL HISTORY OF ELECTRICAL DEVELOPMENT FROM 600 B.C. National Electrical Manufacturers Association, New York, N. Y., 1946. 106 pages, $2. Important innovations and advances in electrical science and technology are listed by the year of their occurrence from the 16th century to date, including six earlier noteworthy events.

RELAY ENGINEERING. By C. A. Packard. Struthers-Dunn, Inc., Philadelphia, Pa., 1945. 640 pages, $3. This is a reference book to guide engineers and others in the selection and use of electromagnetic relays.

INSIDE OF THE VACUUM TUBE. By J. F. Rider. The author, 404 Fourth Avenue, New York, N. Y., 1945. 407 pages, $4.50. Presents a solid, understandable concept of the theory and operation of the basic types of tubes. Discusses the structure and characteristics of various types of tubes. Mathematical calculations have been kept to a minimum.

FUNDAMENTALS OF ALTERNATING CURRENT THEORY. By A. Pen-tung Sah. McGraw-Hill Book Company, Inc., New York, N. Y., 1946. 466 pages, $5. Written from the viewpoint of the operating man rather than that of the design engineer, this book lays particular stress on the operating problems of electric machines.

ELECTRICAL TRANSMISSION IN STEADY STATE. By P. J. Selgin. McGraw-Hill Book Company, Inc., New York, N. Y., 1946. 427 pages, $5. Provides, for students who have had some introduction to the practical aspects of the field, a treatment of the underlying theoretical principles.

ELECTRON OPTICS AND THE ELECTRON MICROSCOPE. By V. K. Zworkyin and others, John Wiley and Sons, Inc., New York, N. Y., 1946. 766 pages, $10. Discusses the various types of electron microscopes and the electron optical theories on which they are based.

Norwegian Short-Wave Transmitter. A new 100-kw short-wave radio transmitter being built near Fredrikstad, Norway, may begin operations by June 1947. The transmitter will be approximately the strength of the largest British transmitter and is expected to be heard anywhere on the globe.

Eta Kappa Nu Resumes Awards to Young Electrical Engineers

After a lapse of five years, Eta Kappa Nu will resume the granting of Recognition Awards to outstanding young electrical engineers.

The awards were discontinued during the war, because of the difficulty of appraising the work of young engineers with so many of them working on classified government projects.

Young electrical engineers who were eligible for the award during the war years still will be eligible, even though now nominally beyond the limits specified. If sufficient, suitable candidates are nominated, it may be possible in 1947 to name a winner and honorable mention recipient for each of the six years from 1942 to 1947. Except for those who do not meet the age requirements (under 35 years of age), all electrical engineering graduates in the class of 1932 or later will be eligible.

Nominations should be sent to A. B. Zerby, Executive Secretary, Eta Kappa Nu, P. O. Drawer C, Dillsburg, Pa., before May 1, 1947. As much information as possible should be given about the nominees, and the award committee will investigate further. Achievement of the nominee may be all or in part in any field including industrial, educational, political, research, civic, artistic, and athletic. Presentation of the awards will be made at a banquet to be held during the AIEE winter general meeting in January 1948.

53 Per Cent Reply in EJC Salary Survey

Tabulation of 47,272 usable questionnaires returned in the 1946 survey of the engineering profession conducted by Engineers Joint Council is under way in Washington, D. C., according to word received from Andrew Fraser, consultant acting for EJC in liaison with the United States Department of Labor's Bureau of Labor Statistics. The replies represent a 53 per cent return from the 86,900 questionnaires sent to members of the six leading engineering societies.

A preliminary analysis indicates that 12 per cent of the professional engineers in the United States were in the Armed Forces some time during the period, 1939–1946, and that in general the services used the special skills of professional engineers to a high degree.

The survey is sponsored by the EJC's Engineer Survey Subcommittee of the Committee on the Economic Status of the Engineer. Co-operation of the Bureau of Labor Statistics was enlisted in the interest of economy, the Bureau being equipped to handle the type of questionnaire used.

Moon as Radio Link Described at Biggest IRE Convention

Current studies of the moon as a passive repeater making possible world-wide microwave communication were revealed by D. D. Grieg (A '39) in a closing session of the 1947 annual convention of the Institute of Radio Engineers held March 3–6, in the Hotel Commodore, New York, N. Y., with a registered attendance of 12,549. In addition, as a service to its members, the IRE sponsored a Radio Engineering Show at the Grand Central Palace in New York at which 170 manufacturers exhibited their products.

Doctor Grieg, of the Federal Telephone and Radio Corporation, Newark, N. J., presented the paper, "Considerations of Moon Relay Communications," written by himself, S. Metzger, and Richard Waer. According to Doctor Grieg, the projected use of the moon to reflect radio waves so far has encountered three problems unknown to conventional radio communication systems: the Doppler shift in the frequency of the received signal due to the relative motion of the earth and the moon; the possibility of interference from cosmic noise; and the fact that contact can be established only while the moon is visible at both transmitter and receiver.

As the exact reflecting properties of the moon's surface are unknown, calculations have been made for the moon as a perfectly smooth reflecter and as a perfectly diffuse reflecter. In the first case, signals of all types would be reflected without distortion; in the second, transmission of telegraph or teletype is practical, narrow band speech is possible, but the transmission of television signals is doubtful. In either case transmitting power is available with existing equipment. Moon reflected signals would be used only for rebroadcast, as they would not always be in range of present home receiver antennas.

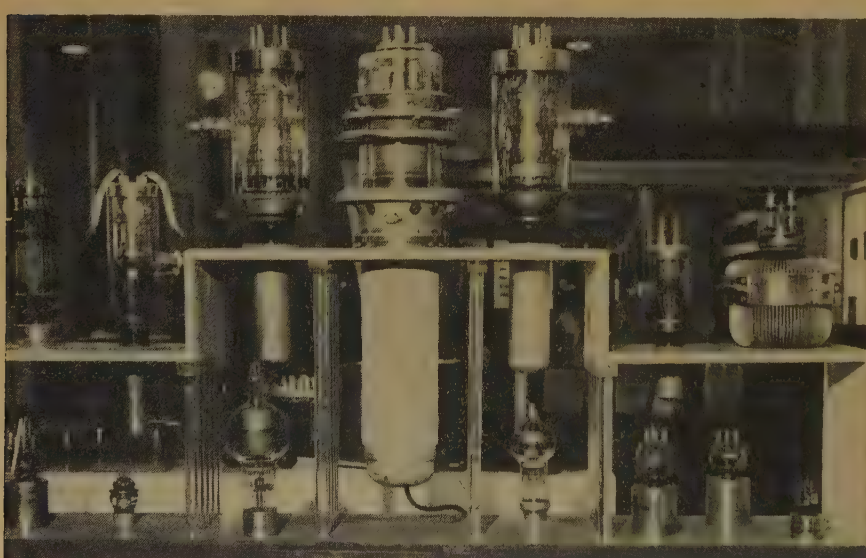
DUTCH TELEVISION

The status of television in Holland was indicated in two papers presented by H. Rinia, visiting engineer from the Philips Laboratories, Eindhoven: "Cathode-Ray Tube and Optical System," by H. Rinia, J. de Gier, and P. M. van Alphen and "High Voltage Unit and Deflection Circuits," by J. Haantjes, C. J. Siezen, and F. Kerkhof.

SYMPOSIUM ON ENGINEERING PROFESSION

A symposium on the engineering profession, at which Doctor W. R. G. Baker (M '41) president of IRE, presided, was held Wednesday afternoon. Doctor Charles B. Jolliffe (M '34) executive vice-president of the Radio Corporation of America, Princeton, N. J., considered the "Relation of the Engineering Profession to Industry," and Doctor Harry S. Rogers president of the Polytechnic Institute of Brooklyn, discussed "Liberal Education of the Engineering Profession."

In view of the dependence of industry on the engineer and the dependence of more than one half of the national economy on industrial activity, the responsibility of the engineer assumes a new order of magnitude, Doctor Jolliffe declared. "To a degree, he is responsible for the inadequate manner in which his technological achievements are being used," he said. "Materialism has been too long in the ascendency. Moral and spiritual values have dropped low on the scale of life," he added.



Tube display of the Federal Telephone and Radio Corporation at the Radio Engineering Show

He urged that engineers promote the application of the scientific method to all the problems of society, scoring as untenable the excuse that "the engineer has no time."

"I see no reason why an engineer cannot take as much part in business and public affairs as lawyers, physicians, and educators. We should break out of our professional shell and become better citizens. In fact, I think a broadening of interest would make us better engineers," he asserted.

The addition of a humanistic-social program to a scientific, technological education is no panacea for the problem of schooling leaders who will solve the most urgent problems of industrial democracy, Doctor Rogers warned his hearers.

Crediting the liberal arts subjects with granting an introduction to social problems, he added, "there is still a great gap between an elementary critical understanding of the problems of the citizenship and the practical behavior of citizens in an industrial democracy."

The liberal arts faculties are themselves in a state of indecision about what sort of program will fill this need, he reminded the audience. Evidence of this lies in the recent action of the American Society for Engineering Education in recommending that humanistic-social studies occupy 20 per cent of an engineering student's time. The ASEE passed by the program and methods of instruction without any specific recommendations, because the liberal arts college had no generally accepted program to meet this need, Doctor Rogers stated.

In defining the central problem of industrial democracy toward the solution of which education programs must be directed, Doctor Rogers said: "It is illuminating to note, however, that the freedoms of the Constitution are 'freedom to'—freedom to worship, freedom to assemble, freedom to speak, and freedom to publish. These freedoms have been disturbed deeply by the introduction of 'freedom from.' The reconciliation of these 'freedoms from' with the 'freedoms to' is the great problem of our industrial democracy."

FCC CHAIRMAN AT BANQUET

Charles R. Denny, chairman, Federal Communications Commission, who was the principal speaker at the annual IRE banquet Wednesday evening, indicated the problems in frequency regulation which the Government is expecting the radio engineer to solve in the near future and outlined the current status of such regulation.

The rapid expansion of radio heating poses two alternate courses of action, he said. These machines either must operate on frequencies assigned to them; or some method must be devised for shielding them, so that they do not radiate.

For the present, the Commission is setting up graveyards at strategic points in the radio spectrum where heating devices can operate without causing interference to radio communication service. Four such

graveyards have been established in the 13, 27, 40, and 2,450 megacycle regions. However, demand for more can not be met without interfering with essential communication services, he said.

The second "headache," Mr. Denny presented to radio engineers was the fact that "the high frequency spectrum is a potential bottleneck to the expansion of world-wide communications, world-wide aviation, and world-wide shipping."

Alleviating this situation will mean devising a method for using the microwaves for communication between continents, according to Mr. Denny, and he mentioned the two methods which have been suggested: airplanes circling in the stratosphere and reflections from the moon.

Revisions in the international allocation table have been worked out by the Commission in an effort to make the most efficient use of frequencies between 4 and 25 megacycles, and will be presented to the 65-nation World Telecommunications Conference convening in Atlantic City, N. J., May 15th, he said. A new plan for allocation of frequencies between 30 and 30,000 megacycles also has been formulated.

Among the 25 engineers who received Fellow Awards at the banquet were the following AIEE members:

L. V. Berkner (M '36) "for his investigations of ionospheric phenomena and his contributions to air-borne radar development."

E. L. Bowles (F '33) "for his activities in making possible the maximum practical use of advanced radio equipment in military operations and for his work in the educational field."

R. S. Burnap (M '29) "for his many technical and administrative contributions to the welfare of the Institute and radio field as an active chairman or member of numerous technical committees."

R. F. Field (M '40) "who, as an engineer and physicist, improved methods and standards in a-c measurements."

D. G. Fink (M '45) "in recognition of his espousal of high standards of technical publishing and for his wartime contributions in the field of electronic aids to navigation."

J. W. McRae (A '37) "for his outstanding work in the planning of research and development programs in radar and countermeasures and for his researches in radio transmitting methods."

I. E. Mouromtseff (A '25) "in recognition of his contributions to vacuum tube development, particularly transmitting tubes."

C. A. Priest (M '45) "for his contributions as an engineer, executive, and organizer in the field of radio transmitter development and design."

Also presented at the banquet were the Morris Liebmann Memorial Prize for 1946 and 1947 to Doctor Albert Rose, of RCA Laboratories Division and to Doctor John R. Pierce, of Bell Telephone Laboratories, respectively. The first award of the Browder J. Thompson Memorial Prize was made to Doctor C. L. Dolph, of Bell Telephone Laboratories. Doctor Rose was honored for "his contributions to the art of converting optical images to electric signals, particularly the Image Orthicon," and Doctor Pierce for "his development of a traveling-wave amplifier tube having both high gain and very great band width." Doctor Dolph was cited for the excellence of his paper, "A Current Distribution for Broadside Arrays Which Optimizes the Relationship Between Beam Width and Side-Lobe Level."

President Baker, FCC Chairman Denny, and Toastmaster Lack at the IRE Banquet

Mr. Fink acknowledging the Fellow Awards at the Wednesday night banquet

F. R. Lack (M '37) vice-president and manager of the radio division, Western Electric Company, New York, N. Y., was toastmaster at the banquet.

The fact that within the memory of living men, science has made greater advances than in the preceding 300 years, is the outgrowth of the present-day faith in the organized efforts of ordinary men, IRE President Baker asserted in his address to the annual banquet. In support of this belief he offered the tremendous advances made in the five years of World War II. "Under peacetime conditions these advances would have taken certainly ten and perhaps 20 years," he explained.

"Science began to have power when it began to be cumulative," he said, regarding the evolution of the specialist as resulting from the spread of organization and the age of specialization as implementing the diffusion of knowledge, the exchange of experience, the codification of practice, and the standardization of usage.

ADMIRAL ADDRESSES LUNCHEON

At a luncheon honoring President Baker, held March 4, Vice-Admiral Charles A. Lockwood, Jr., United States Navy, spoke on "Electronics in Submarine Warfare."

"The advent of radar, IFF, UHF, and VHF communication techniques, when added to the latest in echo ranging and sound equipment," turned the tide of battle in favor of United States submarines in the Pacific, he said.

Stating his attitude toward electronics in peacetime, Admiral Lockwood said; "The secrets incorporated into nearly all of these weapons and equipment are now available for civilian use, and it is my earnest hope that they will be put to work in the economic, medical, and scientific fields for the advancement and happiness of mankind instead of for its destruction."

TECHNICAL PROGRAM

In all, 20 major technical sessions and approximately 30 committee meetings comprised the technical program of the convention which had as its keynote "electronics at peace."

One of the five papers presented at the session on basic electronic research was "The Electronic Research Sponsored by the Office of Naval Research," by E. R. Piore, in which the philosophy and basis of operation of the ONR in supporting fundamental and basic research in electronic laboratories outside the Naval establishment was outlined. For purposes of analysis the current program was divided into propagation, the interaction of radio radiation and matter, the physics of components, systems, and instrumentation.

At a session on air navigation aids operational tests of several proposed systems were described: the Lanac (laminar air-navigation and anticollision) system, the proposed Navar system for navigation and traffic control of the Federal Telecommunications Laboratories, and the application of microwaves to the guidance and control of aircraft.

Two sessions were devoted to atomic energy, one on accelerators for nuclear studies and one on nucleonics instrumentation.

Application of wartime radar and special modulation techniques to peacetime communications also was the subject of two sessions.

At one of the three sessions on microwaves, an adjustable phase changer for microwave transmission was demonstrated. The other sessions dealt with large power tubes for very high frequencies.

New Calculator Operates at Harvard University

Known as "Mark II," a new automatic sequence controlled calculator was presented before a meeting of more than 200 mathematicians at Harvard University, Cambridge, Mass., in January at the official opening of the school's computation laboratory. A 4-day symposium on problems of large-scale computing devices was held at the same time.

The Mark II is approximately 12 times as fast as the Mark I (*EE, Aug–Sept '46, pp 384–91*) also built at Harvard Univeristy, and, although it is slower than the University of Pennsylvania machine (*EE, Mar '47, p 289*), it can handle much more complex problems. Mark II, constructed under the direction of Professor Howard H. Aiken, is all electrical in contrast to Mark I which is electromechanical. This summer the new machine will be transferred to the Naval Proving Ground, Dahlgren, Va., to work on problems of guided missiles, bomb trajectories, and shell characteristics. Rear Admiral C. T. Joy, United States Navy, of the proving grounds, revealed that Harvard University has been asked to survey the field of calculating machines and recommend design for another.

At one symposium session, Doctor Wassily Leontief, of Harvard University, discussed the possibility of conversion of economic problems into pure mathematics and the possibility of solving them with the aid of large calculating machines. He pointed out that the idea is not new but has been impractical.

Also presented at the symposium was a device invented by H. W. Fuller, research assistant at the computation laboratories, for recording results from high-speed computing machines. The invention is centered around a cathode-ray tube on the screen of which numbers are reproduced by the computing machine for rates up to 2,000 per second to be recorded by a camera operating at the same speed. The number of cathode-ray tubes used corresponds to the number of digits in the figures to be recorded.

British Electricity Nationalization. A proposed Electricity Bill, the British government's fifth nationalization measure in 18 months, calls for transfer of the distribution of electricity from 370 local authorities to 14 area boards that will be subject to direction of a British Electricity Authority, a body to be appointed by the Minister of Fuel and Power. The proposed measure calls for public ownership of all organizations supplying electricity, all power station companies serving as generating stations, and all holding companies whose assets primarily comprise power interests. Stockholders of companies, other than local authorities, are to be compensated with an amount of British Electricity Stock which the Treasury shall deem of equal value to the private stock. Local authorities will receive payments covering interest and sinking fund charges on debts.

Mexican Thermoelectric Plant. A 25,000-kw thermoelectric plant will be built at Guaymas, Sonora, Mexico, under the Mexican Federal Electricity Commission. The plant will consist of two 12,500-kw turbogenerators with boilers and complete modern equipment. Waterside location offers the advantages to be had from water transportation of fuel oil, which will be used to fire the boilers. Plans are being made for a high-voltage transmission network which will involve the purchase and installation of necessary high-voltage substations and intermediate and low-voltage distribution equipment.

Russia Doubles Research Expenditures

The current five-year plan of the Union of Soviet Socialist Republics assigns a leading role to the further development of research as a means of achieving a tremendous advance in the productive forces of the country, according to a report of the Finance Minister of the USSR. Expenditures for the maintenance of research institutions were fixed at about $950,000,000 for 1946.

Registration of postgraduate students has filled most of the vacancies at universities and at the research institutes, with 2,850 at the former and 1,600 at the latter. The aim of the Ministry of Higher Schools is to have 10,000 postgraduates in the Soviet Union by 1950, the end of the current five-year period. The postgraduate student receives a state stipend from the moment he is enrolled and is attached to a definite professor who guides him throughout the three years he spends on research.

Co-ordination Established Between Army Groups and Industry

A new link has been established between the Army Signal Corps, the communications services of the Ground and Air Forces, former members of these services, and American industry concerned with communications, electronics, and photography, with the formation of the Army Signal Association.

Purposes of the organization are: to maintain closer relations between civilians concerned with military communications and photography; to preserve and foster the fellowship between former, present, and future interested personnel; to contribute to preparedness through liaison; to inform the public of requirements in the field; to promote co-operation between civilian workers and the Armed Forces; and to assist in developing and maintaining efficient personnel for emergency service.

The association issues a monthly magazine, *Signal Bulletin*, as a news letter; and a bimonthly magazine, *Signals*, of a more technical nature. David Sarnoff (M '23) president of the Radio Corporation of America, New York, N. Y., is acting as president until one is elected in April.

Apartments Are Problem for Television Antennas

The lack of room on the roofs of multiple dwellings for the elaborate individual antennas currently required for television receivers has caused numerous building owners in New York, N. Y., to warn tenants that they can not use television receivers in their apartments.

According to Will Baltin, secretary of the Television Broadcasters Association, the problem is to establish standards by which any make of receiver could be matched to a central aerial circuit. Several different master antenna systems have been produced, but as yet none has gained industry-wide acceptance.

Realty circles agree that a master aerial system would be costly because of the necessity for placing of coaxial cables and shielding from sources of disturbance. However, installation is being considered, and several new apartment buildings in New York will have such systems.

New Magnetic Alloy Developed. Doctor Trygve D. Yensen (M '23) of the research laboratories, and J. K. Stanley, of Westinghouse Electric Corporation, East Pittsburgh, Pa., have developed an alloy of 35 per cent cobalt, 64 per cent iron, and 1 per cent chromium that is claimed to carry more magnetism than any other alloy practical for use in electric rotating machinery. It is claimed that the new alloy, Hiperco, which is tough enough to withstand intense vibration, will make possible motors and generators ten per cent smaller and lighter than those now built for aircraft, because of its high magnetic saturation point. The high cost of cobalt limits the material to applications in which savings in weight and size are important.

Italian Power Shortage. Owing to the shortage of electricity, various Italian industries are being compelled to cut their production by as much as 40 or 50 per cent. Electric power production for the present probably will drop to 75 per cent of the 20-billion kilowatt-hour output of 1942. The High Council for Public Works, together with leading Italian electrical industrialists, has made plans to provide for completion of new plants with annual outputs to increase from 869-million kilowatt-hours in 1947, to 3,432-million kilowatt-hours in 1950.

British Air Lines Co-operate. Three state-owned British air line corporations have formed a nonprofit company to install and operate telecommunications and radio aids to navigation wherever they are required and would not be obtainable otherwise. The object of the company is to aid uniformity in navigational systems, according to Whitney Straight, deputy chairman of the British European Airways.

Electronic Devices Tested in New Navy Hangar

When the Bureau of Yards and Docks completes the hangar now under construction at the Naval Air Test Center, Patuxent River, Md., testing of electronic devices under installed service conditions in all types of Navy aircraft will be possible on a scale never before attempted. The hangar is shielded electronically and will have complete facilities for individual testing on any aircraft from the smallest fighter to the largest type airplane. The shield of galvanized metal wire mesh will be installed around the entire hangar, and the floor will contain two layers. The wire mesh was chosen, not only because of its relative economy as compared with metal sheets, but also because it permits ventilation and admission of light. Water pipes all will be bonded carefully to the shield, and the electric light fixtures will be installed with the mesh fastened to them in such a way that all the interference will be above them. The two million dollar project will not be finished until late in 1947.

Spain to Expand Electricity Production. The need for additional electric power in Spain stems from the government's plan to electrify the state-controlled standard-gauge railways, which will consume an estimated 700 million kilowatt-hours annually. The railroads, which cover approximately 2,800 miles, will be equipped with a 3,000-volt d-c overhead line from substations to be supplied with 3-phase 50-cycle alternating current at from 6 to 150 kv. Following the construction of new hydroelectric and thermal stations, the electric power production of Spain is expected to reach 11,272 million kilowatt-hours by the end of 1956.

Use of Airplane Landing Aids Progresses. Tests have been conducted at Gander Airport, Newfoundland, by Pan American Airways with the participation of American Overseas Airline and British Overseas Airway Corporation on the ground-controlled approach radar landing system in recent months. Meanwhile the Civil Aeronautics Administration has adopted, for installation at 81 major airports in the United States, the landing aid known as ILS (instrument landing system).

Chinese Management Association. The Research Corporation of New York, N. Y., has made a grant of $10,000 to be administered by Stevens Institute of Technology, Hoboken, N. J., for investigations with the purpose of establishing a management association in China. The association would propagate knowledge of modern management and production methods. Doctor C. H. Wu, secretary of the National Resources Commission of China, is co-operating in the project.

Power Restoration at Dneiper Dam. According to the International General Electric Company, the first of three 90,000-kva alternators installed at Dneiper Dam in South Ukraine, Union of Soviet Socialist Republics, has been operated successfully. The original generators were destroyed by the Russians in 1941 to prevent their use by the Germans. Complete electric equipment will not be installed for some months, although power from the three hydroelectric generators can be utilized partially in nearby devastated industrial areas.

Color Television Hearing Concluded by FCC

Charles R. Denny, chairman of the Federal Communications Commission, promised a decision "as soon as possible in view of the problems involved" at the final session in February of the hearing on a petition of the Columbia Broadcasting System to set commercial standards for color television. The Government's verdict opposing the establishment of color standards, which was handed down March 18, will be a major factor in determining whether television set manufacturers will continue manufacture of present type sets.

According to the opponents of the CBS petition, neither the sequential (CBS) or simultaneous systems of color television are ready for commercialization; the major problems to be worked out being: increase of picture size and brightness, increase of color fidelity, and elimination of flicker and noise.

The Radio Manufacturers Association opposed the CBS sequential system on the grounds that maximum obsolescence would result from its adoption. Doctor W. R. G. Baker (M '41) director of the RMA engineering department, presented the RMA views and added that with the simultaneous system the black-and-white receiver designed for present standards may accept, without substantial internal changes, a portion of the color transmission and reproduce from this a picture in monochrome.

Directors for ASA. Six directors were elected recently to serve on the board of the American Standards Association. They are: R. L. Pearson, representing the Association of American Railroads; C. W. Pierce, representing the National Fire Protection Association; J. H. Hunt, representing the Society of Automotive Engineers; J. H. McElhinney, representing the American Iron and Steel Institute; R. O. Kennedy, representing general consumer interests; and A. G. Pratt, representing The American Society of Mechanical Engineers.

New Swiss Power Plants. Six power plants under construction in Switzerland will have a combined total capacity of almost 200,000 kw when they are completed in several years.

EDUCATION . . .

Scholarship Fund for Canadian Engineers

The Engineering Institute of Canada recently announced the inauguration of an educational fund to help deserving engineering or scientific students. The fund is known as the Harry F. Bennett Educational Fund of The Engineering Institute of Canada in memory of the former chairman of the institute's committee on the training and welfare of the young engineer.

A minimum objective of $25,000 was set up for a campaign among the institute membership, but this will cover the needs only partially. It is hoped and anticipated that further endowments will be made by Canadian engineers and other public-spirited individuals.

Harvard Engineers Celebrate. The 100th anniversary of the launching of formal science education in the United States was observed February 13 at a special meeting of the Harvard Engineering Society in New York, N. Y. The original document responsible for the university's inauguration of science education was read. Among those presented with honorary memberships in recognition of outstanding scholarship and accomplishment was Doctor Joseph Slepian (F '27) Westinghouse Electric Corporation, East Pittsburgh, Pa.

INDUSTRY . . . . .

Industrial Relations Award. The Philadelphia, Pa., Chamber of Commerce and Board of Trade made its first annual Industrial Relations Award to Leeds and Northrup Company of that city at a dinner, January 15. The silver plaque award was presented to Charles S. Redding (M '41) president of Leeds and Northrup, by W. L. Batt, president of SKF Industries, Inc., also of Philadelphia. According to C. V. Conole, general manager of the chamber, the award was based on the company's many liberal policies, such as profit sharing, employee stock ownership, and co-operative councils for labor and management.

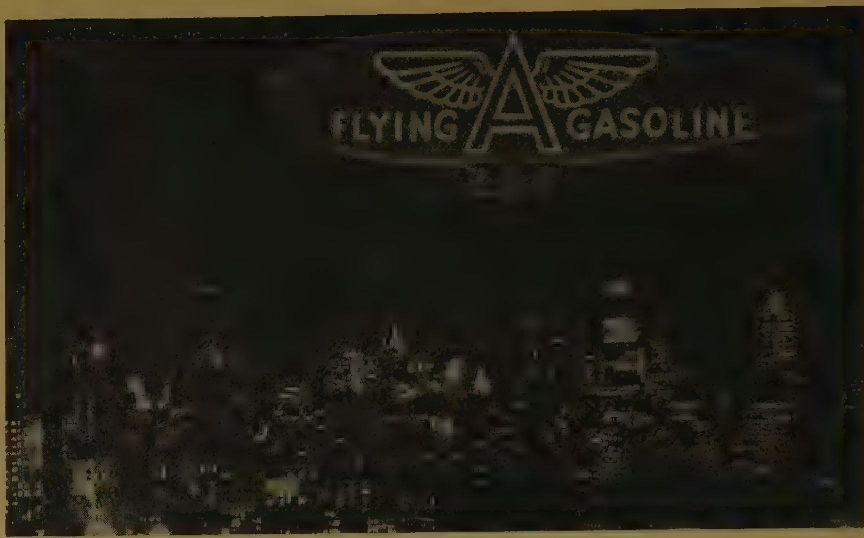
Meter School Held in Vermont. Representatives from eight electrical companies in Vermont, New Hampshire, and Massachusetts were students for a week in January in an electric meter school held at Rutland, Vt., under the direction of the New England Association of Meter Engineers. The course consisted of lectures, demonstrations, and educational films furnished by various manufacturers of electric meters.

Detroit Edison Expands. The Detroit (Mich.) Edison Company has announced a 4-year construction program calling for the expenditure of $96,000,000 to increase the power producing capacity of the system by 22.4 per cent. Included in the plans are two 100,000-kw turbogenerators for the Trenton Channel plant to be in service in 1949 and 15 new substations and 110 miles of rural lines for 1947.

1946 Radio and Television in Production. According to the Radio Manufacturers Association, the production of all types of radio receivers in 1946 exceeded 15 million. Greatest prewar set production was 13,642,334 in 1941. The output of combined frequency and amplitude modulation receivers was 181,485, and the number of television receivers was 6,476.

Utility Seizure Authorized. A law authorizing the governor to seize and operate public utilities as a means of averting strikes has been passed by a special session of the Virginia Legislature. The new law imposes penalties against both sides under seizure as an incentive for them to settle their differences without delay.

New Advertising Method Demonstrated



Tide Water Associated Oil Company's 253-foot Navy K-type airship recently made its first night flight over New York, N. Y. Contacts made through perforations in paper tape similar to that used in player pianos energize relays closing lamp circuits that spell out an advertising message. Three 5-kw d-c gasoline-driven generators are the source of power, and 11,500 28-volt lamps and 480 relays are used in the circuit. The airship will be used to advertise products of the company throughout the United States

OTHER SOCIETIES •

ASTM Dedicates New Building. Doctor E. U. Condon (M '44) director of the National Bureau of Standards, delivered the principal address at the dedication of the new headquarters building of the American Society for Testing Materials in Philadelphia, Pa., February 26. After the ceremonies, at which Doctor G. H. Clamer (M '20) senior living ASTM past president, presented the building to President A. W. Carpenter, who accepted it on behalf of the society, a cocktail hour and dedication dinner were held. Dedication of the building was included in the ASTM spring meeting which featured a symposium on paint.

RWMA Announces New Officers. The Resistance Welder Manufacturers Association at its annual meeting held in Detroit, Mich., in January elected officers for 1947. G. N. Sieger, president of S-M-S Corporation, Detroit, Mich., is the new president, and T. S. Long, vice-president and general manager of Taylor-Winfield Corporation, Warren, Ohio, is vice-president.

ASTE Gains New Chapters. The American Society of Tool Engineers added three new chapters during 1946, bringing the total number to 75. The new chapters are located in Evansville, Ind.; Poughkeepsie, N. Y.; and Madison, Wis.

NSPE Hits Wagner Act. The National Society of Professional Engineers recently called for revision of the Wagner National Labor Relations Act to assure professional employees "their traditional freedom of association and mutuality of action." Legislation was urged which would state that professional employees shall not be required to be members of unions as a condition of employment, and shall retain the right to bargain collectively without being part of an organization not composed exclusively of professional employees.

RMA and NAB Liaison. The first joint conference in many years between the Radio Manufacturers Association and the National Association of Broadcasters was held in February. The meeting was necessarily exploratory, and there was discussion of such interests as exchange of industry statistics, legislative and Federal Communications Commission matters, developments of frequency modulation, and television. One of the major decisions reached was to make "National Radio Week" an annual celebration and for 1947 the week of October 26 was chosen. President R. C. Cosgrove of RMA headed that group and President J. A. Miller of NAB headed the broadcasters at the conference.

RMA Directors Meet in Chicago

Declaring that the radio industry is doing everything possible to expedite the production of combined frequency and amplitude modulation receivers, the Radio Manufacturers Association board of directors at a Chicago, Ill., meeting recently authorized a special committee to canvass RMA manufacturers, prepare a factual report on frequency modulation production, and confer with the Frequency Modulation Association on production problems.

At the same meeting the directors also gave permission to launch a "Radio-in-Every-Room" sales promotion campaign. Some of the other matters presented were: the results of the 1946 National Radio Week, held November 24–30; a report on the RMA appearance at the Federal Communications Commission hearing on color television; and the admission of 12 new members to the organization to bring the total membership to 346, an all-time high.

New England Radio Engineers to Meet. An all-day radio engineering meeting is scheduled by the newly created North Atlantic region of the Institute of Radio Engineers for May 17 at the Hotel Continental, Cambridge, Mass. The meeting will be a new venture in co-operation

among New England electronic specialists. Six technical papers are to be presented on communications, microwaves, frequency modulation, and measurements. A luncheon is planned at noon, and a banquet for the evening with entertainment. Information and advance registrations are being handled by H. H. Dawes, New England Radio Engineering Meeting, 275 Massachusetts Avenue, Cambridge 39, Mass.

Institute of Physics Undergoes Reorganization

Effective immediately, the 7,000 members of The American Physical Society, The Optical Society of America, Inc., The Acoustical Society of America, Inc., The American Association of Physics Teachers, and The Society of Rheology will become members of the American Institute of Physics. Heretofore the institute has been an organization of the five member societies without any individual memberships. According to an announcement in *The Review of Scientific Instruments*, no change is made in the organization, functions, and activities of the five societies.

Plans for a new semipopular journal devoted to physics and its relation to society also have been announced by the institute. The new journal, for which financing now is being sought, will contain news about physicists, their meetings, and their work; information about the action of governmental and other agencies affecting physics; articles and letters presenting the views of physicists on problems of general importance; references to current literature; and so forth.

RESEARCH • • • • •

Engineering Foundation Asks Gifts for Research

Doctor A. B. Kinzel, chairman of the Engineering Foundation, has announced that, in view of postwar increases in opportunities for productive research in engineering, the foundation would welcome bequests and gifts to supplement its current principal fund of approximately $1,000,000. The foundation has been engaged in important research activities for more than 30 years.

Sponsorship and financial support of a research project by the foundation commonly stimulates or enables the obtaining of additional and frequently much larger contributions of money, material, and services from institutions, industry, and individuals. The foundation aided in establishing the National Research Council and its division of engineering and industrial research.

Inquiries about gifts and bequests, which are deductible for Federal income tax purposes, may be directed to John H. R. Arms secretary of the Engineering Foundation, 29 West 39th Street, New York 18, N. Y.

Future Meetings of Other Societies

American Chemical Society. 111th national meeting, April 14–18, 1947, Atlantic City, N. J.

American Foundrymen's Association. 51st annual convention, April 28–May 1, 1947, Detroit, Mich.

American Public Power Association. Fourth annual convention, May 21–23, 1947, Cleveland, Ohio.

American Society for Engineering Education. 55th annual meeting, June 18–21, 1947, Minneapolis, Minn.

American Society for Testing Materials. 50th annual meeting, June 16–20, 1947, Atlantic City, N. J.

American Society of Mechanical Engineers. Semiannual meeting, June 16–20, 1947, Chicago, Ill.; fall meeting, September 1–4, 1947, Salt Lake City, Utah.

American Welding Society. Annual meeting, October 20–24, 1947, Chicago, Ill.

Association des Ingénieurs. Centenary congress and exhibition, August 30–September 13, 1947, Liége, France.

Canadian Electrical Association. 57th annual convention, June 18–20, 1947, St. Andrews, New Brunswick.

Edison Electric Institute. June 2–5, 1947, Atlantic City, N. J.

Electrical Manufacturers Representatives Club of New England. Trade show, June 4–6, 1947, Boston, Mass.

Illuminating Engineering Society. East central regional conference, May 8–9, 1947, Washington, D. C.; Midwestern regional conference, May 15–16, 1947, Kansas City, Mo.; annual convention, September 15–19, 1947, New Orleans, La.

Institute of the Aeronautical Sciences. Light aircraft meeting, May 26–27, 1947, Detroit, Mich.

Instrument Society of America. Second national conference, September 8–12, 1947, Chicago, Ill.

International Lighting Exposition and Conference. November 3–7, 1947, Chicago, Ill.

Midwest Power Conference. March 31–April 2, 1947, Chicago, Ill.

National Association of Corrosion Engineers. April 7–10, 1947, Chicago, Ill.

National District Heating Association. 38th annual meeting, June 24–27, 1947, Atlantic City, N. J.

National Electrical Manufacturers Association. October 27–31, 1947, Atlantic City, N. J.

National Electrical Wholesalers' Association. May 5–9, 1947, Atlantic City, N. J.

National Electronics Conference. November 3–5, 1947, Chicago, Ill.

National Fire Protection Association. 51st annual meeting, May 26–29, 1947, Chicago, Ill.

National Plastics Exposition. May 5–11, 1947, Chicago, Ill.

National Safety Congress and Exposition. October 6–10, 1947, Chicago, Ill.

New England Radio Engineers. May 17, 1947, Cambridge, Mass.

Pacific Chemical Exposition. October 21–28, 1947, San Francisco, Calif.

Refrigeration Equipment Manufacturers Association. All-Industry Refrigerating and Air-Conditioning Exposition. January 26–29, 1948, Cleveland, Ohio.

Rural Electrification Administration. National convention, April 22–25, 1947, Spokane, Wash.

Society of Automotive Engineers. Summer meeting, June 1–6, 1947, French Lick Springs, Ind.

Society of Motion Picture Engineers. 61st semiannual convention, April 21–25, 1947. Chicago, Ill.

Society of Naval Architects and Marine Engineers. Spring meeting, May 23–24, 1947, Washington, D. C.

Southern Machinery and Metals Exposition. Second annual meeting, April 14–17, 1947, Atlanta, Ga.

Bureau of Standards in Radioactivity Research

The Radioactivity Section of the National Bureau of Standards, Washington, D. C., has established a new laboratory to test performance qualities, utility, and construction of Geiger-Müller counters and associated electronic measuring equipment because of the increasing demand for reliable, stable instruments.

Commercial production of such instruments has been undertaken only in the past eight or nine months, and, because of the lack of uniformity in types and designs now becoming available, no attempt can be made to set up standard specifications for them. It is expected that co-operation between the laboratory, purchasers, and manufacturers will produce the background of experimental and operational data for this.

Because of the Bureau of Standards facilities and experience in the field of radioactivity, radiological organizations, medical groups, the Manhattan District, and the International Commission of Radiation Protection and Radiation Dosage are looking to it for extension of X-ray measurement research, and standards development activities into the 50- and 100-million-volt range. The work will be accomplished with two betatrons to be installed in a special building authorized by Congress in 1946. Co-operation is planned with the National Cancer Institute and the Carnegie Institution of Washington.

MIT Reconverts Spectroscopy Laboratory

The spectroscopy laboratory at the Massachusetts Institute of Technology, Cambridge, is now in the process of reconversion after being devoted almost entirely to work for the Manhattan District during the war. Prior to the war the laboratory was part of the physics research laboratory, and its activities were concerned primarily with physicists' problems. The scope of the MIT program in spectroscopy has been enlarged to include research in biology, chemistry, geology, and metallurgy, as well as physics. Among the specific research programs that have been planned are ones sponsored by the Office of Naval Research and the American Petroleum Institute. Doctor R. C. Lord is present director of the laboratory.

Researchers Join Bureau of Standards. Doctor H. D. Holler, a leading authority on underground corrosion, has been appointed to the National Bureau of Standards, Washington, D. C., to work in conjunction with Doctor I. A. Denison of the Underground Corrosion Section. The Atomic Physics Section of the bureau is now under the direction of Doctor J. A. Hipple, formerly section manager in the electrophysics division of the research laboratories, Westinghouse Electric Corporation, East Pittsburgh, Pa.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

An Analysis of Electromagnetic Forces

To the Editor:

I have read with much interest W. A. Tripp's article, "An Analysis of Electromagnetic Forces," (*EE, Oct '45, pp 351–6*) and the ensuing correspondence between him and A. Gronner (*EE, June '46, pp 300–02, and Dec '46, pp 596–8*).

On pages 136–40 of my book, "Fundamentals of Electromagnetism," (Macmillan Company, New York, N. Y., 1939) will be found a calculation of the force between two parallel current elements using only electrostatic forces, with relativity modifications, and the calculation leads to the well-known and accepted result. The calculation further shows that the force depends entirely on the motion of one charge relative to another and that, if the moving negative charges in the two conductors have equal velocities in the same direction, the total force is due only to the reactions between these negative charges and the stationary positive charges on the atoms of the conductors. If the "observer" in the usual formulation of the relativity-corrected forces is taken to be a *test charge* (for no observer can detect the existence of electric forces without the aid of test charges), the results of the theory may be interpreted in a common-sense manner as giving the mutual force between charges.

E. C. CULLWICK (M '33)

(Captain, Royal Canadian Naval Reserve, Defence Research, Department of National Defence, Ottawa, Ontario, Canada.)

The Motional Mass of the Electron

To the Editor:

C. A. Boddie in his article on "The Motional Mass of the Electron" in the January 1947 issue of *ELECTRICAL ENGINEERING* deserves much credit for reviving the concepts of equivalent mass and other mechanical characteristics of the electric field. His view is not new, having been suggested first by Faraday. Without giving credit to those who amplified the concept of the Faraday tubes of force, these views seem to be most ably expounded in Starling's "Electricity and Magnetism for Advanced Students."

The notion of longitudinal tension and lateral pressure is discussed on page 128 of Starling where due credit is given to the dielectric constant of the medium in determining the tensions and pressures.

A demonstration of the velocity of propagation in this neomechanical medium is given on page 543 of Starling along with the determination of the lateral mass of these tubes on page 432.

In fact the very question of mass and electric field in motion is discussed on page 545 where it is pointed out that:

> Heaviside (Volume 1) has shown that for a charge moving with a velocity v, the distribution of electric displacement ($D=kE$) is the same as though the body were at rest, but the dielectric constant in the direction of motion were reduced in the ratio $1-(v^2/c^2)$ where c is velocity of light. This effect would therefore be small for velocities much below that of light and if the velocity of light could be attained, the value of k (dielectric constant) would be zero. Hence the Faraday tubes, as the velocity increases, tend to become more and more displaced towards the equatorial plane, that is, into a position in which their motion is at right angles to their length, and their effective mass increases. In the limiting case when $v=c$ they are confined to an infinitely thin sheet at right angles to the direction of motion. The value of D and likewise the electromagnetic mass of the charge, then being infinite.

The parenthetical expressions were added by myself in explanation of those symbols previously used by Starling.

The difference in results indicated by Starling (mass of the electron becomes infinite as $v \rightarrow c$) and Boddie (mass of the electron stays constant) seems to lie in the fact that, after developing the lateral mass of the electric field, Boddie ignores the work which must be done to accelerate it.

Boddie's picture of the field distribution around the moving charge seems to follow that of Starling, except that in ignoring the effect of motion on the dielectric constant Boddie must make the assumption (equations 22 and 23) that the effective field decreases with velocity in order to satisfy the Einstein equation. Heaviside would seem to prove, according to Starling, that the effective field increases with velocity, since at the velocity of light the dielectric constant is zero and the field must be corresponding large as it is inversely proportional to the dielectric constant.

In summary, Mr. Boddie's mechanistic views of the electric field are interesting, but not novel. He is not consistent in the application of these views and therefore is led to erroneous conclusions via questionable assumptions.

HERBERT SHERMAN (A '40)

(Staff engineer, Watson Laboratories, Eatontown, N. J.)

To the Editor:

The article by C. A. Boddie entitled, "The Motional Mass of the Electron," which appeared in the January 1947 issue of *ELECTRICAL ENGINEERING* presents some propositions which warrant careful consideration. The author is to be complimented for offering a level-headed discussion of reported experimental results and sounding a timely warning against the unsubstantiated extrapolation of those results when they involve factors which go to infinity as some variable approaches a particular value. The fact that the factor $(1-\beta^2)^{-1/2}$ gives results which correspond reasonably well with theory over 80 per cent of the range of variation of β between zero and unity should not blind us to the fact that this factor varies only from 1.00 to about 4.63 within this range but varies from 4.63 to infinity over the 20 per cent of the range not covered by experiment. This certainly is an extreme range of extrapolation. It should be a challenge to human ingenuity to investigate it, rather than an opportunity for human frailty and conceit to point with pride at the insignificant range that has been investigated.

However, Mr. Boddie's analysis contains features which require elucidation and further support. In the theories to which Mr. Boddie objects, the electron commonly is supposed to have different values of mass, transverse and longitudinal with respect to its velocity. He quotes only one, the transverse, his equation 1, but actually deals with both, and in different ways. In the treatment encompassed by his equations 5–14, he disposes of the transverse mass factor by using the value of field intensity transverse to a moving Lorentz electron. The longitudinal mass factor is explained away by assuming a function, his equation 22, by which the field fails to follow up because of its mechanical characteristics, this assumed function being just sufficient to counterbalance the change of mass involved. A more complete justification for the use of two different methods would be helpful. Moreover, it should be explained why the longitudinal field intensity of the moving Lorentz electron, which is $(1-\beta^2)$, was not specified as part of the factor in equation 22.

Mr. Boddie's general concept is strongly mechanistic, a procedure which frequently leads to inconsistencies if great care is not exercised. For instance, his Figure 6 for static conditions gives a picture which seems to lead logically to Figure 7 for nonstatic conditions, until one reconsiders Figure 6 in the light of what the effect on an additional electron would be. The whole of electrostatics is built upon the premise that electric fields are directly additive. However, in discussing Figure 6 Mr. Boddie says: "The function of the main field E_0 is to compress the electron flux. . . ." Certainly if field fluxes can push each other around in this manner, they cannot be directly additive.

Another question which requires an answer is this: If the failure of the field to follow up immediately leads to the function in equation 22, what is the value of this function when the electron is moving into the field? Some other questions are:

What is happening on the other side of the electron? What are the conditions for fields and charges of other signs?

WILLIAM A. TRIPP (M '35)

(Electrical engineer, Charles T. Main, Inc., Engineers, Boston, Mass.)

To the Editor:

Mr. Boddie's article on "The Motional Mass of the Electron" in the January 1947 issue is highly entertaining to a thoughtful mind. Reaching ably down into the ultramicrocosmic with mathematical tongs, he concludes the electron is a hollow sphere whose mass resides entirely in an enveloping electric field. What is this mass? Apparently it is an aspect of field.

While the equations and experimental data deal with moving electrons, it must not be forgotten that the electron is not conceived of as ever at rest. And furthermore, the experiments and equations consider only electrons accelerating through an electric field in an approximately straight line, which of course is rather different from conditions found within the atom itself, where the electron is believed to be traversing a circular orbit around a central detaining mass, wherein the atomic radius and the electronic velocity are such that the number of revolutions per second must be prodigious—about 10^{15}! This appears to be in accordance with a well-known law of celestial mechanics which states that orbital motion describes equal areas of arc per unit time regardless of distance from the central detaining mass.

Because of the considerations of size, all the known laws of physics, dynamics, mechanics, may appear distorted when dealing with the electron. Perhaps the electron is an ultimate, as would seem to be the case with velocity of light.

Now if the electron be an ultimate, our mathematical tongs will need some revision, lest the whole approach to the subject be found finally to be a mathematical fiction, as Mr. Boddie so aptly terms the electric charge of the electron. This electric charge, appearing at the terminus of tubes of electric flux, merely defines the cross sectional or areal value of the flux under consideration. By the same reasoning, how do we know that all our equations and concepts are not similarly 3-dimensional termini of n-dimensional entities? We ought not, as he says, confuse the terminal hook with the helical spring. By further analogy, the helical spring itself may be merely a device supporting the real entity, which indicates much deeper probing is needed to remove the remaining paradoxes.

The enormous stresses he calculates at Appendix V are not so unreal when we consider some aspects of the minute volume of the electron sphere. For instance, the force of mechanical tension is deducted as 7.55×10^{21} tons per square centimeter at electron surface. Trouble is, we haven't got anything like a square centimeter of electron surface to consider. For any one electron we have only a region of hemispherical surface approximating 14×10^{-26} square centimeter and an arc of spherical surface curving more sharply than anything we can visualize. Thus the strength of spherical arch involved would be enormous per unit distance, although it does not follow that we are dealing here with any physical junction.

One other fact worth noting is the weight aspect of the individual electron. Where mass is 9×10^{-28} grams and electron radius is 1.87×10^{-13} centimeter, the total number of all electron spheres which would contiguously fit into a volume of 1 cubic centimeter would be 20×10^{36}, and the total weight of such an aggregation would be over 200 metric tons! Such a mass in 1 cubic centimeter volume would, of course, immediately sink to the center of earth's gravity. Why then does not the individual electron similarly sink to the center of gravity, since it has the same relative weight? There is an answer, and a valid one, but I leave that to the mathematicians.

In contemplating macrocosmic vastness the human imagination finally sinks exhausted, though it be aided by the science of number. So also in contemplating the ultramicrocosm, imagination sinks exhausted in trying to grasp the ultimate meaning of definitions. For example, the equations define electrons falling (accelerating) through an electric field; but when the equation is finally resolved, the electron itself is found to be a special type of electric field, whose entire mass resides in—therefore is—electric field. Thus we have an electric field of density X accelerating through an electric field of density Y.

This electric field has inertia, pressure, lateral tension, and so forth. But what is it? This incorporeal substantiality—does it exert pressure by means of kinetic discrete particles, subelectronic in size, or, must it be considered as a gravity-like continuum, the force of which is neither undular nor derived from quanta?

I conclude that several pertinent facts are still missing from the rebus.

D. J. STRUVEN (A '43)

(Engineer, priority co-ordinator, Westinghouse Electric Corporation, Bloomfield, N. J.)

To the Editor:

I have read with great interest C. A. Boddie's article on the motional mass of the electron. He has dealt with an abstruse electrophysical problem in a lucid, engineering style without resorting to the "supermathematics" of the relativists and atomic physicists. In fact, the scarcity of integrals and differentials together with the complete absence of curls, tensors, and so forth is noteworthy considering the subject. Whether or not we concur in the author's conclusions, we must feel a sense of satisfaction that a practical electrical engineer has dealt so competently and clearly with a subject of fundamental physical importance.

The paper has brought to my mind some questions and ideas directly or indirectly related to the article which may be of interest or at least provide food for thought.

1. The author refutes the theory of increase of mass of an electron moving in and propelled by an electrostatic field. Would the refutation apply to the electron moving at high velocity of its own momentum but not in an electrostatic field? What about the increase of mass of any body in motion, charged or uncharged?

2. The author considers an electrostatic field to possess inertia. Would he also give inertia to an electromagnetic field? And what about a gravitational field, could it be considered to possess inertia?

3. According to relativity theory, a body in motion is foreshortened in the direction of motion. Is the electron considered by the author foreshortened, or does this turn out to be apparent only as is the increase of mass.

4. In most discussions of moving electrons, neutrons, protons, and so forth, (which I will refer to generically as particles), the kinetic energy is taken to be $\frac{1}{2}Mv^2$, where M is the mass and v the linear velocity of the particle. However, it is neither reasonable nor probable that a moving particle should be completely devoid of any rotation or spin with respect to the reference system of co-ordinates. The particle also must possess energy of rotation in the form of $\frac{1}{2}I\omega^2$, where I is its moment of inertia about axis of spin and ω is the angular velocity. The total kinetic energy of the particle must be the sum of these or $\frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2$. Clearly, ω may be so large that the rotational energy exceeds the energy of linear motion. Then why is this rotational energy ignored so generally simply because we are unable to determine ω. Suppose the electron discussed by the author were spinning rapidly, would this spin affect the equations and conclusion or may it be totally ignored?

5. Many experiments depend upon measurement of the deviation of the path of a particle in motion by electrostatic and electromagnetic fields. If these particles are considered to be spinning at high angular velocities, is not the gyroscopic action to be allowed for in the computations?

6. If we decide to give consideration to the spin of a moving particle, then we must be prepared to ask ourselves just what influence has the direction of the axis of spin relative to the direction of motion. . . .

7. Under extreme conditions, there are certain deviations from the well-known laws of gases (Charles' and Boyle's Laws). These laws are based on the kinetic theory of gases. If we consider that the gas molecules also are spinning as well as moving about, then the interchange of rotational energy with lineal energy by means of collisions among molecules and with walls of container may account for the deviations in the laws.

8. Although it is seldom realized, it is a fact that a body can be made to spin on more than one axis simultaneously. It appears also that, in the case of a sphere at any rate, all the rotations on any number of axes can be resolved to three rotations on three mutually perpendicular axes. . . . However, rotation of a body on more than one axis is inherently an unstable condition and . . . to arrive at the stable condition requires time. Now, in considering subatomic particles, this interval of time, although infinitesimally small, still may be a large portion of the life of the particle or at least its life while under observation. In considering a particle, we therefore must consider not only its spin but also the number of axes on which it may be spinning and the relation of the angles of these axes with the direction of linear motion and the reference co-ordinates . . . it might form the basis for a hypothesis under which the observed characteristics of a particle are determined by its energy of rotation and the distribution of this energy on three axes. Indulging in pure speculation, we might look forward to learning that electrons, protons, neutrons, and deuterons are fundamentally the same particles, differing only in the distribution and amount of rotational energy. This would be in line with the thought that nature did not need a multiplicity of building blocks for the fundamental structure of energy and matter but has used a single basic unit which we have been observing in various forms.

I wish to say, with respect to "triaxial" rotation, that I have built a model in which a sphere is forced to revolve on one,

two, or three mutually perpendicular axes (at the same angular velocity). There are some curious effects, one of which is the ability of the device to translate energy applied in the form of harmonic vibration to rotational energy.

In closing I must apologize for seeming to have wandered so far from the subject of Mr. Boddie's article, but relativity, kinetics, particles, and fields, in the last analysis, all figure in the ultimate nature of mass and energy.

CHARLES B. SAXON (M '42)

(Consulting engineer, New York, N. Y.)

To the Editor:

In the article, "The Motional Mass of the Electron," of the January 1947 issue of *ELECTRICAL ENGINEERING*, the author, C. A. Boddie, claims that the mass of an electron is a constant and does not depend upon its velocity. He claims to be able to explain the results of all experiments performed to prove the variation of mass with velocity, by the laws of Newtonion dynamics which suppose the mass to be constant. To demonstrate this point the deflection experiments as used by G. G. Thompson are treated in full detail in equations 5–14 of the article. I would like to take issue with the author on this point, which is the whole foundation of the conclusion derived in the succeeding paragraphs of his article.

Let us consider the same case as presented in equations 5–14 by the author. If an electron beam of velocity v is shot through a deflecting electrostatic field E the measured deflection of the beam is *less* than the calculated value, assuming the mass constant and the deflecting force independent of the velocity. This discrepancy is explained, in the established theory, by the variation of mass with velocity. The author claims to be able to explain this experimental result by assuming the mass constant and the deflecting force *increasing* with velocity. It is apparent that the variation of deflecting force with velocity has to be in the opposite direction in order to explain the experimental results. It is obvious then that the interpretation of the mathematically correct equation 14 should be in error. Experimental measurements of r, H, and E are in accordance with equation 14 only when equation 8 is valid. Equation 8 has, however, been replaced by equation 12, and consequently it can be concluded that the experimental results can not be explained without having to assume a variation of mass with velocity.

A more careful consideration of equation 12 is also of considerable interest. With $v/c=B$, equation 12 is written

$$B=\frac{E}{H}\frac{1}{\sqrt{1-B^2}}$$

or

$$B^2(1-B^2)=\frac{E^2}{H^2}$$

$$B^4-B^2+\frac{E^2}{H^2}=0$$

$$B^2=\pm\frac{1}{2}\sqrt{\frac{1}{4}-\frac{E^2}{H^2}}$$

If this equation were correct, values of $E/H > {}^1/_2$ would lead to imaginary values of B. I do not think that this conforms with experimental results.

N. L. KUSTERS

(Electrical engineering and radio branch, National Research Council, Ottawa, Ontario, Canada)

To the Editor:

The January 1947 issue of *ELECTRICAL ENGINEERING* invites comment on an article by C. A. Boddie, "The Motional Mass of the Electron." I should like to point out that the arguments through equation 14 are already incorrect.

The error in the argument consists in computing the force on the electron due to the electric field E in a reference frame in which the electron is at rest, then computing the force due to the magnetic field H in a frame of reference in which the electron has velocity v, and then equating these two forces!

One must use one frame or the other as follows:

1. Reference frame of the laboratory.

E_0 and H_0 are at rest. The electron has velocity v. The balance equation is $eE_0=H_0(ev)/c$ correctly given in the paper as equation 7.

2. Reference frame moving with the electron.

The electron is at rest in this frame. E and H are *both* moving with velocity $-v$. Equation 10 of the paper gives correctly the change of the electric field due to its motion, namely

$$E_v=\frac{E_0}{\sqrt{1-\left(\frac{v^2}{c^2}\right)}}.$$

But H is also moving in this frame of reference. A moving magnetic field exerts a force on a stationary charge; in fact it contributes to the electric field in this frame on amount

$$-\left(\frac{v}{c}\right)\frac{H_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

The balance equation thus reduces precisely to equation 7.

Thus we may conclude that the paper contains not a "new approach" but an erroneous analysis.

MORTON HAMMERMESH

(Assistant professor of physics, New York University, N. Y.)

Aids for the Blind

To the Editor:

I wish to call your attention to an error which at least is implied in the interesting article by T. A. Benham on "Aids for the Blind" which appeared in the February issue of *ELECTRICAL ENGINEERING*. In the first paragraph at the top of page 182, Mr. Benham describes a supersonic guidance device on which he states that "the Haskins Laboratories are working." Actually, the development of guidance devices for the use of the blind has been a co-operative venture in which a number of organizations, including the Haskins Laboratories, have been engaged. Development of frequency modulated supersonic systems has been carried on in at least two organizations, including the Stromberg-Carlson research department, one of whose systems apparently is the one described by Mr. Benham.

Our work on this problem originally was undertaken under contract from the Office of Scientific Research and Development and has been continued since the war under sponsorship first of the National Academy of Sciences and later of the Veterans Administration. The work has been under the general supervision of the Committee on Sensory Devices mentioned by Mr. Benham. During the progress of our development program, we have worked closely with the Haskins Laboratories, which organization not only has worked on the development of guidance devices but also has had the responsibility of making the very necessary psychological tests required in evaluating the performance of blind aids developed by us and by other organizations engaged in the work under contracts paralleling ours. The work of the Haskins Laboratories has been invaluable in determining the requirements which must be met by guidance devices in order that they may be of maximum use to the blind, in indicating the deficiencies of the equipment developed by the various organizations participating in the program, and in pointing out the direction in which future work should progress. I do not believe, however, that either the Haskins Laboratories or a responsible representative of that organization would claim that their group was solely, or even primarily, responsible for the development of the device described, as at least is implied by Mr. Benham.

We feel gratified that of the many different guidance systems developed by those co-operating with the Haskins Laboratories in this program, one of ours was deemed worthy of description. We feel, however, that Mr. Benham not only is incorrect in assigning credit for the work, but also that any description of the work is regrettable. We have refrained from publishing the results of our work on blind guidance devices, because we have felt that we had a definite responsibility in not encouraging blind persons and their friends to believe prematurely that satisfactory guidance devices would be available soon. The results of the work to date are encouraging, but much work remains to be done before (or if) all problems can be solved. If Mr. Benham had approached us with a request to describe our system, we would have emphasized this viewpoint and would have recommended that he refrain from mentioning the work. We know that, at least in the past, this has been the attitude of

other groups engaged in this type of work.

GEORGE R. TOWN (M '37)

(Manager, engineering and research, Stromberg-Carlson Company, Rochester, N. Y.)

Dear Mr. Town:

I am in receipt of a copy of your letter of February 11 to G. Ross Henninger, editor of *ELECTRICAL ENGINEERING.*

I appreciate your comments on my article on aids for the blind and hasten to extend my apologies for having omitted reference to your organization. I am sure that no one at the Haskins Laboratory would underestimate your contributions to the field of guidance devices for the blind.

Being blind myself and interested in future developments, I feel strongly that a sensible educational program to inform the blind as to efforts and progress in sensory devices is a very desirable stimulus to the hope in the future for those who are anxious to become "free and independent." Evidence that such a program is considered worth while is given by the fact that the American Foundation for the Blind has placed an order for reprints of the article.

However, this article was not written for blind readers, nor has it been published to date in a magazine which blind people in general will read. Furthermore, I am of the opinion that I stated rather forcefully that no development to the present time or even in the foreseeable future is going to revolutionize "foot travel" for the blind. I pointed out that to date the dog is the best guide because of its ability to think for itself. I am sure that the tenor of the article is such that no blind person hearing a true, undistorted résumé would feel that freedom and independence of movement were just around the corner! Granted, the sensational, spectacular, type of headlines that the inconsiderate press might give the résumé would misrepresent the facts, but I did not write the article for this type of press. As I stated in the closing paragraph, the article was intended to stimulate interest, comments, suggestions, and even research on aids for the blind together with an improved attitude in the industrial placement of the blind. Your feeling is justified somewhat however, as, unfortunately, this paragraph, which follows, was not printed:

"All this activity ultimately will improve the conditions under which blind persons are laboring today. But there is need for much greater effort. Charles G. Ritter of the American Foundation for the Blind, 15 West 16th Street, New York, N. Y., or the author will welcome any suggestions that interested readers care to submit. Ideas pertaining to new lines of endeavor or instruments which, if developed, would enable blind men and women to be self-supporting and to take their place in the community more easily and completely, are particularly sought. Any suggestion, no matter how trivial it may seem, perhaps will mean a better job for someone."

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NEW BOOKS • • •

"Mutual Survival—The Goal of Unions and Management." This is the first of a series of *Interim Reports* relating to the results of research currently being conducted by the Yale University Labor and Management Center on various problems basic to and understanding of labor and management relations and to the advancement of psychological and social science. The conclusions concerning "Effective Unions and Sound Management" given in the report directly reflect the results of extensive personal interviews conducted by the author in nine major centers of industrial activity in the East and Middle West involving 60 each of leading representatives of management and organized labor in those centers. These representatives were recommended as persons of broad interest and experience with collective bargaining and represented all shades of reaction from the antagonistic to the unusually co-operative; each was encouraged to speak freely under a pledge of strict confidence. "Industrial warfare will plague America until leaders of labor and management understand and respect the survival needs of each other. Management has deep convictions, born of experience, about the 'principles of sound management.' Labor leaders have convictions, born of experience, about the 'principles of effective unionism.' Each is convinced that if he compromises his principles he encourages a threat to his own survival. Many labor leaders believe that if unions become the kind which management labels 'sound,' they will cease to be 'real' unions. Most employers believe that if management yields much more to union pressure, it will cease to be 'real' management. These beliefs keep both in a basically fighting mood. Each group sees in the attitudes, actions, and policies of the other a threat to his own survival. . . . . The basic issue in labor–management relations at the moment, then, arises from the fact that each party is concerned primarily with its *individual* survival. Preoccupied . . . . they have forgotten a very fundamental truth: That sovereignty in a democracy must be shared, not exclusively possessed by any particular group . . . . The result of failure to work out the means of *mutual survival* will not be the elimination of one group by the other, but elimination of both groups as free institutions by public regimentation." The essential substance of the first chapter of Professor Bakke's report, embracing his summary and conclusions, already has appeared (*EE, Feb '47, pp 124–30*). By E. Wight Bakke, Sterling Professor of Economics and director of Yale University Labor and Management Center, New Haven, Conn. Yale Labor and Management Center, 1946, 6 by 9 inches, paper, single copies, $1; 25 or more, 75 cents.

"Electrical Engineering." This book is intended as a text in electrical engineering for students specializing in other fields of engineering. The fundamental theories and methods of analysis are presented in a simple manner. However, the book is not limited to basic concepts. Many typical applications are presented to teach additional theoretical material and to reinforce the student's understanding of the fundamentals. The book is well illustrated with both diagrams and pictures. Simple illustrative problems are given; no solutions are published in the book. The English system of units is used throughout. By Fred H. Pumphrey (M '25). Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y., 1946, 369 pages, 6 by $9^1/_2$ inches, $5.35.

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

MICROCALORIMETRY. By W. Swietoslawski. Reinhold Publishing Corporation, New York, N. Y., 1946. 199 pages, illustrated, $9^1/_4$ by 6 inches, cloth, $4.75. The purpose of this book is to give a comprehensive description of the methods used in measuring small amounts of heat developed by different objects. The first ten chapters are devoted to principles, methods of operation, and equipment of various types of microcalorimeters, with discussion of their applications. The final chapter is concerned with the choice of a method with regard to the requirements of any given determination. Possible fields of use include physics, physical chemistry, physiology, biology, metallurgy, and industrial research.

NATIONAL FIRE CODES. Volume II. The Prevention of Dust Explosions, 1946. National Fire Protection Association, Boston, Mass. 224 pages, illustrated, $9^1/_4$ by 6 inches, cloth, $1. Following a brief general discussion of the fundamental principles for prevention of dust explosions in industrial plants, this manual presents 17 specific codes for various industries. New in this edition is a code covering the plastics industry and appendix material on explosion venting and static electricity, in addition to revisions of more than half of the established codes. A record of dust explosions in the United States, classified by industry, is appended. This list does not include dust explosions in mines or ordnance plants.

LA PRATIQUE INDUSTRIELLE DES TRANSFORMATEURS. By M. Denis-Papin. Preface by L. Barbillion. Editions Albin Michel, Paris, France, 1946. 184 pages, illustrated, 10 by $6^1/_2$ inches, paper, 210 francs. The object of this book is to discuss electric transformers from the point of view of modern usage, for which the customary theories and approximations are often insufficient. The mathematical fundamentals are reviewed in accordance with this aim, and a new presentation permits the student to establish actual transformer projects instead of imaginary ones. Calculations, construction details, and test and installation methods are discussed, with numerical problems directly applicable to the daily work of the technician. For the designer a number of original researches are presented.

SPECIFICATIONS AND TESTS FOR ELECTRODEPOSITED METALLIC COATINGS. Sponsored by American Society for Testing Materials and American Electroplaters' Society, November 1946. American Society for Testing Materials, Philadelphia, Pa. 46 pages, 9 by 6 inches, paper, $1.25 (to ASTM and AES members, 95 cents). Seven specifications for electrodeposited coatings and two test methods are brought together in this publication for convenient reference. All have been prepared jointly with the American Electroplaters' Society with the exception of the salt spray test. Also included are two recommended practices for chromium plating on steel and the preparation of low-carbon steel for electroplating.

ANALYTICAL EXPERIMENTAL PHYSICS. By H. B. Lemon and M. Ference, Jr. University of Chicago Press, Chicago, Ill., revised edition, 1946. 588 pages, illustrated, 12 by 9 inches, cloth, $8. The whole range of basic physics is covered effectively in this new textbook. The fundamentals of the major divisions—mechanics; heat; electricity and magnetism; wave motion, sound, and light—are covered in detail, with clear, brief treatments of more advanced topics, for example: the production of very low temperatures; nuclear fission; the electron microscope; the scientific aspects of music. The use of successive frames of motion-picture film in demonstrating experiments is a special feature. The text, queries, problems, and illustrations all have been designed to provide a clear, readable presentation of a customarily difficult course in order to stimulate the student's interest. The book is, of necessity, large, but provision is made for individual selection of the material to be used.

BIBLIOGRAPHY OF STATISTICAL QUALITY CONTROL. By G. I. Butterbaugh. Published for the Bureau of Business Research of the College of Economics and Business by the University of Washington Press, Seattle, Wash., 1946. 114 pages, 9 by 6 inches, paper, $1.50. The references contained have been chosen carefully to make certain that the statistical aspect is emphasized, and annotations are provided to assist in selection of the most useful items. Part I lists magazine articles, arranged alphabetically by name of magazine and for each magazine consecutively by date of appearance. Part II lists manuals, monographs, and pamphlets alphabetically by the companies or organizations responsible, and part III lists books by author. A combined author index for the more than 700 included items is provided.

LIGHT METALS MONOPOLY. By C. F. Muller. Columbia University Press, New York, N. Y., 1946. 279 pages, illustrated, 9 by 6 inches, cloth, $3. Based on material brought to light by two antitrust cases in aluminum (1937–1945) and magnesium (1941–1942), this publication is an economic study of the position held by the Aluminum Company of America as a monopoly in the aluminum industry. The author shows how important monopolies have developed and describes their effect on the production and development of the light metals. Three factors have been emphasized: control of power sources; international cartel relations; and control of a substitute, magnesium. The relation of government policy to monopolies is examined, and alternatives are suggested to cope with the basic economic problem.

MECHANICAL MEASUREMENTS BY ELECTRICAL METHODS. By H. C. Roberts. Instruments Publishing Company, Pittsburgh, Pa., 1946. 357 pages, illustrated, $8^1/_4$ by $5^1/_2$ inches, cloth, $3. This new book describes in detail all the methods for electrically measuring displacements, pressure, vibrations, strain, accelerations, and so forth, including the basic principles of the circuits and systems. Capabilities and applications are discussed, and auxiliary devices—such as amplifiers, oscillographs, and calibrating devices—are dealt with as well as the main equipment. Several hundred footnotes and a supplementary bibliography indicate further available material in the field of electric gauging.

MEXICAN-AMERICAN CONFERENCE ON INDUSTRIAL RESEARCH, September 30–October 6, 1945. Apply to S. C. Pappageorge, Armour Research Foundation of Illinois Institute of Technology, 35 West 33d Street, Chicago 16, Ill. 176 pages, illustrated, 9 by 6 inches, paper, $2.50. The 22 papers presented at the conference are printed here in full, describing representative types of university research, foundation research, government research, and research in private industry in a wide variety of fields. General patterns of research, both national and international, are discussed, and the value of standards to American industry is considered briefly together with some descriptions of the work of two large standardizing bodies, the American Standards Association and the National Bureau of Standards.

SCIENCE. By D. W. Hill. Chemical Publishing Company, Brooklyn, N. Y., 1946. 114 pages, $8^3/_4$ by $5^1/_2$ inches, cloth, $2.75. In a series of seven essays the author briefly discusses the scientific outlook and the effect of science on industry, politics, war, education, religion, and leadership. The object of the whole is to demonstrate that the application of the scientific method of thinking, to these diverse fields can lead to social and economic, as well as technical, progress.

PLASTICS BUSINESS. By H. R. Simonds and J. V. Sherman. D. Van Nostrand Company, New York, N. Y., 1946. 439 pages, illustrated, 9 by $5^1/_2$ inches, cloth, $5. This new work, the result of the collaboration of a consulting engineer and an economist, deals primarily with the business and statistical aspects of the rapidly growing plastics industry. Certain technical features, such as the characteristics of the materials involved, are discussed, and the allied fields of plywood and synthetic rubber are considered briefly. The principal producers of plastic parts are classified, and there is an alphabetical list of trade names.

PRINCIPLES OF RADAR. By members of the staff of the Radar School, Massachusetts Institute of Technology, Cambridge. Second edition, McGraw-Hill Book Company, New York, N. Y., and London, England, 1946. Paged in sections, illustrated, 9 by 6 inches, cloth, $5. Originally prepared for use in war training courses, this comprehensive work has been revised to bring the subject matter up to date. It begins with a brief description of the components and functions of radar systems and continues with detailed discussion of typical system components. The intent has been to give a technically thorough and accurate treatment with minimum dependence upon mathematics. Emphasis in the treatment of circuits is upon quantitative analysis directly from tube characteristics and physical principles.

RADIO TUBE VADE-MECUM. Sixth edition, 1946. By P. H. Brans. Editions Techniques P. H. Brans, 28 Rue du Prince Léopold, Antwerp (Borgerhout), Belgium. 232 pages, illustrated, $10^1/_2$ by $7^1/_4$ inches, paper, 105 Belgian francs. The first seven tables of this manual are the same as in previous editions and are as follows: characteristics of the most widely used tubes, including static characteristics and working data; characteristics of tubes less used on the Continent, chiefly British; listing of tubes having same electrical characteristics as certain ones in Table I; tubes with approximately similar characteristics for use as replacements; diagrams of tube sockets; characteristics of Russian tubes; Allied Army tubes corresponding to commercial tubes. This 1946 edition also includes the characteristics of German and Italian army tubes. All headings are given in Dutch, French, English, and German. The directions for use in the 1946 edition are in English only.

FUNDAMENTALS OF SUCCESSFUL MANUFACTURING. By G. G. Hyde. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1946. 201 pages, illustrated, 9 by $5^3/_4$ inches, cloth, $2.50. This book provides executives with a basic analysis of the fundamentals of modern manufacturing, in establishing a new enterprise or modernizing an existing one. Stressing the importance of good organization and developing an objective viewpoint of manufacturing problems, the book covers in detail such topics as designing and processing the product, housing the enterprise, personnel practices, management controls, and so forth, and also covers designing, formalizing, evaluating, and staffing the organization.

RADIO'S CONQUEST OF SPACE. By D. McNicol. Murray Hill Books, New York, N. Y., and London, England, 1946. 374 pages, illustrated, $8^3/_4$ by $5^1/_2$ inches, cloth, $4. Beginning with a review of certain electrical inventions and developments that preceded radio, this book presents, in generally chronological order, a narrative of the experimental achievement by which radio has reached its present status. Along with the descriptions and discussions of technical developments, an account is given of the men who contributed to these developments and the manner in which these achievements were realized. The final chapter discusses the expanding sphere of radio.

TRIGONOMETRY REFRESHER FOR TECHNICAL MEN. By A. A. Klaf. McGraw-Hill Book Company, Inc., New York, N. Y., 1946. 629 pages, illustrated, $8^1/_2$ by $5^1/_4$ inches, cloth, $5. Plane and spherical trigonometry are presented for the use of the man who wants to apply them to various technological fields. Features of this comprehensive treatment include a simplification of the principal functions of an angle, a progressive development of logarithms, and an extensive chapter on the theory, construction, and use of the straight slide rule. Problems in mechanics, surveying, electricity, aerial and sea navigation, light, physics, and hydraulics are presented.

STATISTICAL QUALITY CONTROL. By E. L. Grant. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1946. 563 pages, illustrated, $9^1/_4$ by 6 inches, cloth, $5. This book deals with the laws of probability that may be used to improve acceptance procedures and thus secure the best possible quality assurance from a given inspection cost. It explains the Shewhart control chart and its use in manufacturing to reduce costs of spoilage and rework and to obtain better co-ordination among design, production, and inspection.

PAMPHLETS • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Overhead Line Charts. By J. S. Forrest. Electrical Review, Limited, Dorset House, Stamford Street, London, S. E. 1, England, 1946, 20 pages, 2*s*/6*d*.

Equitable Light and Power Rates. By W. R. Tingle. 114 West 10th Street, Charlotte 2, N. C., 1946, 60 pages, $1.

New Standards for Magnet Wire. National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y., 1947, 14 pages, $1.

Statistics of Electric Utilities in the United States for 1945. Federal Power Commission, Washington, D. C., 1946, $2.

The Financial Record of the Electric Utility Industry, 1937–45. Federal Power Commission, Washington, D. C., 1946, 14 pages, no charge.

Resistance Welding Manual. Resistance Welders Manufacturers Association, 505 Arch Street, Philadelphia, 6, Pa., 1947, 552 pages, $3.

Accident Prevention Manual for Industrial Operations. National Safety Council, 20 North Wacker Drive, Chicago 6, Ill., 1947, 554 pages.

January 1936–June 1942 Index for Philips Technical Review. Elsevier Book Company, Inc., 215 Fourth Avenue, New York 3, N. Y., 20 pages, no charge.

Work Measurement Project. By Ralph M. Barnes. 111 Engineering Building, University of Iowa, Iowa City, Iowa, 15 pages, no charge.

Settled Peacefully. United States Department of Labor, Washington, D. C., 6 pages, no charge.

American Standards. American Standards Association, 70 East 45th Street, New York 17, N. Y., 23 pages.

1946 NEMA Job Rating Manual and Guide for Use of NEMA Manual. Industrial Relations Department, National Electric Manufacturers Association, 155 East 44th Street, New York 17, N. Y., manual, $1; guide, $1.50.